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Alfred Gundersen was born in 1877 in Kragerö, Norway, where his father was a dealer in ship supplies. At the age of fifteen he went to live with his brother in the Cascade Mountains, Oregon. He studied at Stanford University (A.B., 1897), where he majored in physics, becoming also interested in evolution problems under David Starr Jordan.

He then studied botany, at the University of Minnesota, under Conway MacMillan and was, for four years, a high school science teacher. Later he studied anthropology at Harvard University (A.M., 1907). Thereafter, three years were spent in France, at the Ecole d'Anthropologie and at the Sorbonne, working in botany under Gaston Bonnier. Mr. Gundersen prepared his thesis on the *Caprifoliaceae,* in part, at the Laboratoire de Biologie Végétale, Fontainebleau, and obtained the degree of Docteur de l'Université de Paris (botany, geology, anthropology) in 1910.

Returning to Boston, Dr. Gundersen was for three years assistant to Alfred Rehder at the Arnold Arboretum. In 1911 he married Mina Westbye of Trysil (Norway). In 1914 he joined the staff of the new Brooklyn Botanic Garden, where he remained for thirty-two years, at first in the herbarium, and later as Curator of Plants, engaged in building up the living collections of the Garden.

After the publications of Rendle's and Hutchinson's books in 1925 and 1926, he became more and more interested in the classification and evolution of dicotyledons and the interrelationships of the families.

While connected with the Brooklyn Botanic Garden, Dr. Gundersen travelled widely in North America and Europe. In 1930 he attended the Cambridge International Botanical Congress.

Dr. Gundersen retired in 1945 and lives most of the year in his mountain home, in the Catskills, N. Y.

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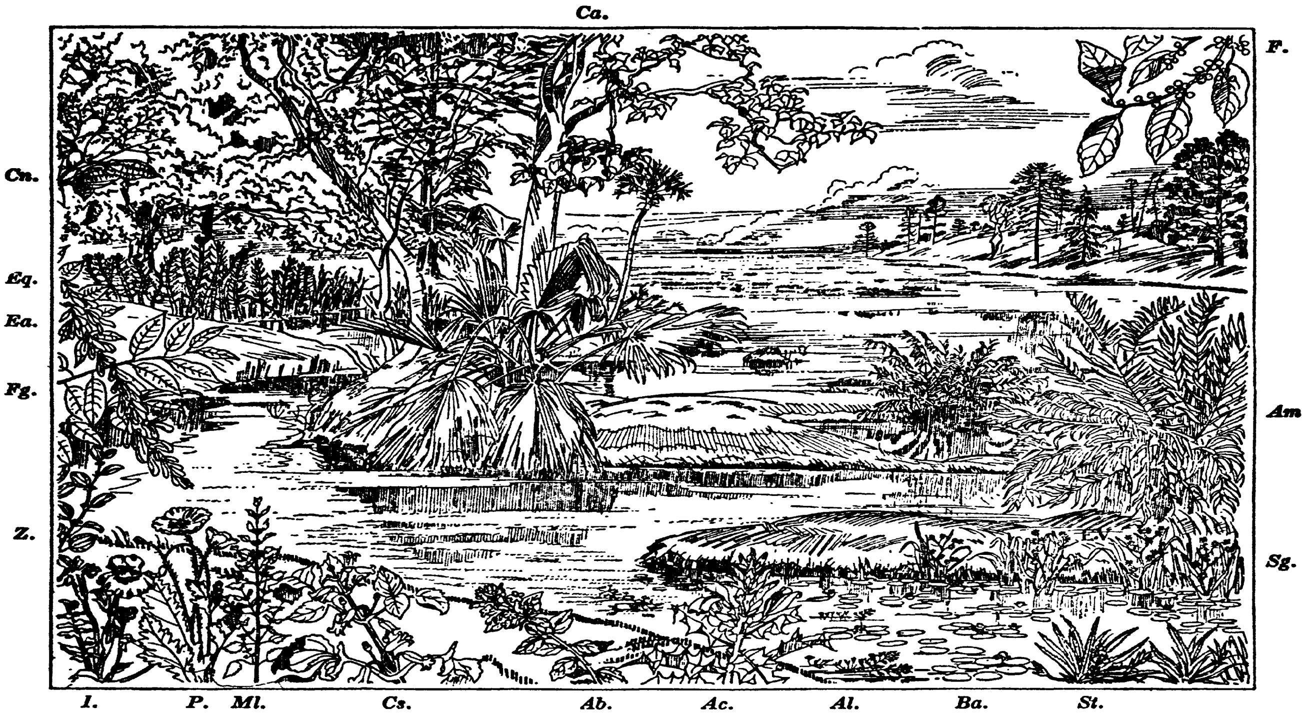
Volume XXV

FAMILIES
of
DICOTYLEDONS



RECONSTRUCTION OF AN OLIGOCENE LANDSCAPE IN THE ISLE OF WIGHT (drawn by Mr. EDWARD VULLIAMY). Ab. *Abelia;* Ac. *Acanthus;* Al. *Aldrovanda;* Am. *Acrostichum;* Ba. *Brasenia;* Ca. *Catalpa;* Cn. *Cinnamomum;* Cs. *Clematis;* Ea. *Engelhardtia;* Eq. *Equisetum;* F. *Ficus;* Fg. *Fagus;* I. *Incarvillea;* Ml. *Melissa;* P. *Papaver;* Sg. *Sparganium;* St. *Stratiotes;* Z. *Zizyphus.* The flora consists of a mixture of elements now living in temperate Europe with others which are more tropical or subtropical. *(From* SEWARD'S 'Plant Life through the Ages' by permission of the Cambridge University Press.)

FAMILIES
of
DICOTYLEDONS

by

ALFRED GUNDERSEN
Curator of Plants, Emeritus, Brooklyn Botanic Garden

With introductory chapters by CHESTER A. ARNOLD,
OSWALD TIPPO, THEODOR JUST, HERBERT F. COPELAND,
J. HERBERT TAYLOR, *and* W. H. CAMP.

Drawings by MAUD H. PURDY

1950

WALTHAM, MASS., U.S.A.

Published by the Chronica Botanica Company

First published MCML
By the Chronica Botanica Company
of Waltham, Mass., U. S. A.

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PREFACE

In 1925 RENDLE *outlined the classification of dicotyledons, following* ENGLER *in the main, but with interesting departures toward the* BENTHAM *and* HOOKER *system. The following year* HUTCHINSON *described and illustrated 264 families of dicotyledons, to a large extent separating woody and herbaceous plants. Important new lines of research have developed, and a natural classification of dicotyledons is still a task for the future.*

Coöperating botanists begin the present publication with statements on fossil dicotyledons, wood anatomy, carpels and ovules, embryology, cytotaxonomy and plant geography. More than half the book is taken up by the separate families, which include brief citations from recent literature. The family sequence at first followed the numbers of DE DALLA TORRE *and* HARMS *(1907), the same as the Brooklyn Botanic Garden collections Gradually various changes have seemed advisable, such as:*

(a) *to begin with Winteraceae, Magnoliaceae and other families with mostly separate carpels;*

(b) *to follow these by groups with usually parietal placentation;*

(c) *to place most "Amentiferae" after Hamamelidales;*

(d) *to place Ericales near Theales, Caryophyllales near Primulales, and Umbellales near Rubiales.*

Yet, the systems of ENGLER *and of* BENTHAM *and* HOOKER *have been in large part followed, especially in the many cases where they agree. Fascinated by the endless diversity of flowering plants the writer has long been interested in a too comprehensive subject; the arrangement adopted is only tentative, not to be accepted but to be improved. He now prefers* HUTCHINSON'S *position of Santalales near Celastrales to that given in this book. In all 240 families are grouped into 42 orders; the orders are compared with those of* SKOTTSBERG *(1940) on page 48.*

I must express my high appreciation to Miss MAUD H. PURDY, *whose skillful drawings have nearly all been prepared from living plants, a few from herbarium material; they often show differences between flower buds and adult flowers, suggestive of phylogenetic trends.*

With pleasure I express my appreciation to many botanists who have coöperated in this work, in particular to:—

Dr. GEORGE S. AVERY, JR., *Director of the Brooklyn Botanic Garden, who in 1944 suggested the preparation of this work in book form; to Dr.* A. H. GRAVES, *also of the Brooklyn Botanic Garden, who has advised on many parts and has read the proof; to Professor* A. J. EAMES, *Cornell University, who has advised on many points.*

My special thanks are due to those who have written the introductory parts: Professor C. A. ARNOLD *on paleobotany, Professor* OSWALD TIPPO *on wood anatomy, Dr.* THEODOR JUST *on carpel morphology, Dr.* H. F. COPELAND *on embryology, Professor* J. H. TAYLOR *on cytotaxonomy, and Dr.* W. H. CAMP *on plant geography.*

Dr. H. A. GLEASON, *New York Botanical Garden, has written the description of Melastomaceae, Dr.* H. N. MOLDENKE, *New York Botanical Garden, has advised on Verbenaceae; Dr.* W. E. MANNING, *Bucknell University, on Juglandaceae; Dr.* H. F. COPELAND, *Sacramento College, on Ericaceae.*

Professor I. W. BAILEY, *Harvard University, Dr.* B. O. DODGE, *New York Botanical Garden and Professor* EDWIN B. MATZKE, *Columbia University, have given welcome advice.*

The valuable periodicals, Biological Abstracts and Botanical Review, have been constantly consulted and of particular use.

The notes on chromosome numbers have, in most cases, been taken from DARLINGTON *and* JANAKI-AMMAL *(cf. p. 221).*

I am under particular obligation towards Mrs. J. G. VERDOORN and Miss H. DE VRIES, *of the Chronica Botanica staff, for their assistance with the proofs and the preparation of the index.*

ALFRED GUNDERSEN

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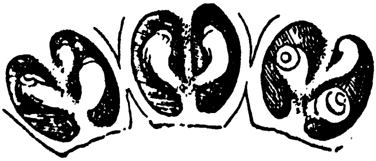

To the Memory of

Gaston Bonnier
(1853 — 1922)
Membre de l'Institut de France
Professeur de Botanique à la Sorbonne

and

C. Stuart Gager
(1872 — 1943)
Director, Brooklyn Botanic Garden

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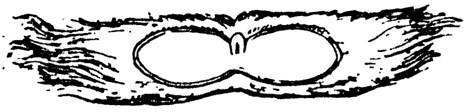
ABBREVIATIONS

I. — One millimeter (drawings)
II. — one centimeter (drawings)
Afr. — Africa
alt. — alternate
BH — Bentham and Hooker, 1880
carp. — carpellate
Diels — Engler-Diels, 1936
dioec. — dioecious
e. — eastern, etc.
esp. — especially
Eu. — Europe
fam. — family
fl. — flower
fr. — fruit
gen. — genus or genera
H or Hutch. — Hutchinson, 1926
I. — Island
incl. — including
infl. — inflorescence
integ. — integument(s)
lvs. — leaves
Medit. — Mediterranean Region
mm. — millimeter
monoec. — monoecious
n. — northern, etc.
N. Am. — North America
ne. — northeastern, etc.
opp. — opposite
Pflfam. — Engler, Pflanzenfamilien, 2nd. ed.
Pflreich. — Engler, Pflanzenreich, 1900-1939
plac. — placentation
Rdl. — Rendle, 1925
S. Am. — South America
sec. — section
st. — stamen
ste. — staminate
subfam. — subfamily
Temp. — Temperate Regions
TH — De Dalla Torre and Harms, 1907
Trop. — Tropical Regions
W or Wetts. — Wettstein and Wettstein, 1933-1935

Family names are often abbreviated in the bibliography, *e.g.*, Aristol., Magnol., etc. For full names *see* Index, page 229 *seq.*



Part 1

INTRODUCTION

Reconstruction of a Cretaceous Flora showing early representatives of the *Magnoliaceae, Platanaceae* and *Sterculiaceae* (*from* Saporta).

FOSSIL DICOTYLEDONS

by Chester A. Arnold
(University of Michigan)

The sedimentary rocks of the earth constitute a vast repository of relics of life of the past. These rocks not only furnish information on the kinds of organisms that have existed at different times, but they yield data unobtainable elsewhere on the history of groups of organisms and their relationships to other groups.

The fossil record shows that flowering plants ascended to their place of dominance in the plant world during the Cretaceous period some 40 million years before the close of the Mesozoic era. Although the Mid-Cretaceous marks the point in the geological column where flowering plants became dominant, the class has a longer history that reaches well back into the Mesozoic era. Just when they first came into existence, or what their immediate ancestors were, we do not know, but we can safely assert that by the time of their earliest appearance in the rocks they had already experienced a long and diversified evolutionary course that has not yet been revealed. No flowering plants have been found in the Paleozoic. The oldest Mesozoic strata are almost equally devoid of them. The first suggestion of a true angiosperm in the lower part of the Mesozoic system is furnished by some leaves named *Furcula granulifera* from the Rhaetic (late Triassic) in eastern Greenland. In shape, venation and stomatal characteristics these leaves are typically dicotyledonous, and were they to be found in late Cretaceous rocks they would be classified with the dicotyledons without hesitation. The family affinities, if it is truly a dicotyledon, are undetermined.

Silicified wood resembling that of the *Winteraceae* and the homoxylous *Magnoliaceae* occurs in rocks believed to belong to the Jurassic period in India. This discovery, reported a few years ago by SAHNI, is of great interest to those concerned with evolution within the dicotyledons because it lends paleontologic support to assumptions drawn from comparative anatomical studies of living plants that the type of wood structure present in these modern families is both ancient and primitive. The oldest fossils that are angiospermous beyond all question are pollen grains from the Jurassic of Scotland. One type is almost indistinguishable from that of a modern *Nelumbium,* and another resembles *Nymphaea.* This early occurrence of waterlilies is quite in agreement with evidence based upon floral morphology that the *Nymphaeaceae* are old as well as primitive.

The degree of suddenness with which the angiosperms became dominant during the Cretaceous period is well shown when we compare the proportions of angiosperms with other types in the Potomac group of lower Cretaceous age with proportions revealed in the Dakota sandstone of early upper Cretaceous age. In the Potomac group flowering plants comprise a minority of types ranging from 6% of the total in the lowermost beds (Patuxent) to about 25% in the highest strata (Patapsco). In the Dakota flora, by contrast, flowering plants make up about 90% of the whole. Thus within the relatively short length of time (geologically speaking) between the lower and upper Cretaceous, the modern era of plant life began.

Many modern dicotyledonous families appear to have become well established during upper Cretaceous time. Some are the *Magnoliaceae, Cercidiphyllaceae, Lauraceae, Moraceae, Euphorbiaceae, Nymphaeaceae, Salicaceae, Ebenaceae, Leguminosae, Hamamelidaceae, Platanaceae, Rhamnaceae, Sapindaceae, Aceraceae, Anacardiaceae, Juglandaceae, Betulaceae, Fagaceae, Araliaceae,* and *Cornaceae.* Some families that may have had a Cretaceous existence but of which the determinations are uncertain are the *Menispermaceae, Tiliaceae, Ulmaceae, Rosaceae,* and *Vitaceae.* Then there are numerous families that have no known Pre-Tertiary records, a few of which are the *Berberidaceae, Dilleniaceae, Sterculiaceae, Rutaceae, Simarubaceae, Malpighiaceae, Oleaceae, Saxifragaceae, Cactaceae, Celastraceae,* and *Caprifoliaceae.* Prominent present-day families either without known fossil representatives or known only on the basis of remains of questionable identity are the *Campanulaceae, Compositae, Labiatae, Ranunculaceae, Scrophulariaceae, Solanaceae,* and *Umbelliferae.* The scarcity or lack of these families in the fossil record may be due not to their absence during the past but to the fact that they are mostly herbs, which do not find their way readily into situations where they may be preserved as do the leaves and fruits of deciduous trees.

In North America there are about one-half as many families of dicotyledons known in the fossil condition as there are living families. Fossil remains of some genera are found that are not native in North America at present. A few such are *Ailanthus, Dipteronia, Cebatha, Cercidiphyllum,* and *Dodonaea.*

The literature dealing with fossil dicotyledons is voluminous and in some respects misleading as to the actual history of some genera. The older authors described numerous "species" of fossil plants based solely upon leaf fragments which in many instances were not completely preserved. Some of these writers were not familiar with enough genera of modern plants, with the result that they tended to assign too many fossil forms to the rather few genera with which they happened to be particularly acquainted. Then these relatively few genera were overloaded with species which in many instances merely represent normal variations within one or a few natural species. The literature on Cretaceous and Cenozoic plants contains many more species of *Ficus* and *Sassafras* (to choose two examples at random) than there is evidence that ever existed. Of the former, more than 150 fossil species have been described from North America, most of which, if properly identified, would be found to belong to other genera or to be merely variations within a smaller number of species.

Modern research on fossil flowering plants is concerned much more than formerly with the natural associations of ancient types. We assume that in the past ecological adaptations of genera were essentially similar to present day adaptations, and by taking these facts into account, ancient floras can be better understood than if environmental factors are ignored as they have been very often during the past.

Being the latest products of evolution in the plant kingdom, the flowering plants are still in their initial stages of expansion, and we cannot view them with the same degree of objectivity as we can certain of the lower groups such as the lycopods and ferns. The fossil record of the angiosperms has thrown but little light on problems of family relationships and developmental trends within the class.

... Of the eight known groups of seed-bearing plants the pteridosperm — cycad — cycadeoid lines seem to be nearer to angiosperms than are the cordaites — ginkgo — conifer lines. The relationships of the angiosperms to other seed-bearing plants, living and fossil, may be better understood by comparing these, as follows:

Cordaitales:— Trees with long, slender, simple leaves and flattened, embryoless, naked seeds borne in strobiloid inflorescences. Paleozoic.

Ginkgoales:— Trees with simple, terminally cleft, fan-shaped or linear leaves borne in part on dwarf shoots, and naked, fleshy seeds in greatly reduced strobili. Late Paleozoic to Recent.

Coniferae:—Trees with scalelike, awlshaped, or needlelike leaves, and naked seeds containing embryos in strobiloid inflorescences. Late Paleozoic to Recent.

Pteridospermae:—Semi-woody or shrubby plants with frondlike foliage, and embryoless naked seeds borne singly on modified or unmodified frond ramifications. Paleozoic and early Mesozoic.

Cycadales:— Sparsely branched, dioecious plants with columnar or tuberous stems containing a thin woody cylinder, a crown of large frondlike leaves, and seeds in cones on sporophylls evidently of foliar origin. Late Paleozoic to Recent.

Cycadeoidales:—Monoecious or dioecious plants of cycadlike aspect, but with seeds produced in expanded flowerlike inflorescences either terminal or lateral on the trunks. Mesozoic.

Gnetales:—Normally dioecious plants with shrubby, climbing, or tuberous stems, simple opposite leaves, vessels in the wood, and naked seeds borne in flowerlike inflorescences. Recent.

Angiospermae:—Woody and non-woody plants with vessels, true flowers, and carpel-enclosed seeds formed from ovules containing rudimentary gametophytes. Middle Mesozoic to Recent.

WOOD ANATOMY

by OSWALD TIPPO

(University of Illinois)

During the past three decades, plant anatomists have established a number of lines of phylogenetic specialization in the structures of the stele. Just as the taxonomists have worked out trends in the evolution of the flower, so the following lines of anatomical specialization have been described:

The prostostele is more primitive than the siphonostele or the dictyostele (*i.e.*, eustele of BREBNER).

In the Angiosperms, the woody stem of trees and shrubs is more primitive than the stem of herbaceous plants.

The vessel element with scalariform perforation plates preceded those with a single opening in the perforation plates. Among the vessel elements with scalariform perforation plates, the type with numerous bars and narrow openings is more primitive than the type in which there are few bars separating wide openings. Vessel elements which are long, small in diameter, and angular in cross-section preceded those which are short, broad, and circular in cross-section. Vessel elements with long, sloping end-walls are more primitive than those with end-walls which are transverse.

The phylogenetic order of the several types of pitting on the side walls of the vessels is scalariform, transitional, opposite, and finally alternate.

The type of vessel arrangement in which the pores occur singly throughout the wood (*i.e.*, solitary pores) is less advanced than the various aggregate groupings, such as pore multiples, pore clusters, and pore chains. The diffuse-porous condition is more primitive than the ring-porous state.

Evolution has proceeded from tracheids to fiber-tracheids to libriform wood fibers. Accompanying this development there has been a progressive decrease in the length of these elements. So far as tracheids are concerned, the phylogenetic development in the Angiosperms has been from scalariform tracheids to circular bordered pitted tracheids.

The diffuse arrangement of wood parenchyma cells is more primitive than are the various aggregate arrangements, such as banded apotracheal and the various paratracheal types, such as vasicentric, aliform, and confluent.

Heterogeneous rays, that is, rays with vertically elongated cells as well as radially elongated cells, are less specialized than are homogeneous rays, that is, rays in which all the cells are radially elongated.

Woods with non-stratified cells are more primitive than those with storied structure.

Among those who have established the above trends are JEFFREY, EAMES, BAILEY, SINNOTT, TUPPER, FROST, KRIBS, BARGHOORN and others.

We may now consider how these lines may be used in phylogenetic studies. The method may be described in the following terms: The anatomy of a given group is investigated, particular attention being given to the characters involved in the sequences already described, although other characters may prove to be useful too (TIPPO, 1941). Next, the pertinent schemes of systematists, usually based on floral morphology, are examined. Then, data are accumulated from other branches of botany, such as paleobotany, cytology, nodal anatomy, pollen morphology, embryology, developmental anatomy, etc. The relationships of the several taxonomic entities are then interpreted in the light of the trends of structural specialization, and an attempt is made to harmonize the evidence derived from the various fields. Instead of basing phylogenetical conclusions on one part, the evidence secured from all parts of the plant is employed.

This method is not an attempt to substitute anatomical characters for those of external morphology. The anatomist admits readily that if he were rash enough to attempt the creation of a phylogenetic system based on features of the vascular system alone, some very weird results would crown his efforts, at least weird as viewed from the standpoint of our present concepts of classification. This is attributable to the fact that vessels and other wood structures have undoubtedly undergone similar phylogenetic development in unrelated groups. In other words, parallel and convergent evolution have occurred. Consequently, the presence of simple perforation plates in the vessels of two groups does not necessarily imply genetical affinity. Of course, similar situations obtain in classifications founded on flower structure. It has, therefore, become increasingly evident that claims that flowers, or vascular structures, or that some parts of plants are universally more conservative than other parts, are unrealistic. Rather it appears, as BAILEY and HOWARD (1941) have pointed out, that the rates of phylogenetic change differ in the various parts and organs of plants, and thus the development of one structure may be accelerated or retarded in comparison with the evolution of other regions in the same plant or group of plants. Furthermore, there is no constant relationship among these rates, for in some groups the flower forges ahead, while the wood lags; whereas in other groups, the anatomical features may develop at a more rapid rate. Consequently, in our endeavors to construct a natural system of classification we must consider, and weigh carefully, and harmonize, and integrate the evidence from all parts of the plant, and from all branches of botany, including anatomy, genetics, cytology, physiology, embryology, paleobotany, etc.

We may now consider specific cases where the utility of these anatomical lines has been demonstrated. We may very well begin with the problem of the origin of the Angiosperms, or the "abominable mystery" as CHARLES DARWIN styled it. Are the *Magnoliales* primitive as asserted by HALLIER, BESSEY, and HUTCHINSON; or are the "Amentiferae" the least specialized, as indicated by EICHLER, ENGLER, and by WETTSTEIN? The evidence from wood anatomy supports the former hypothesis, for the *Magnoliales* have a very primitive array of anatomical characters. Some genera lack vessels, while most have scalariform perforation plates exclusively. The vessel elements are characterized by great length, small diameter, steep end-walls, angular cross-sectional appearance, and scalariform intervascular pitting. The woods are diffuse-porous, and the pores have a predominantly solitary arrangement. The fibrous tracheary elements in many species are tracheids exclusively; all such elements are very long. Many plants in this group have heterogeneous rays. Some have diffuse parenchyma. Almost all are arboreal in habit. On the basis of wood anatomy, there is much to recommend the *Magnoliales* as a very primitive order.

On the other hand, many of the members of the "Amentiferae" have simple perforation plates exclusively, they are ring-porous, and their vessel members are often short, round, large, and with opposite or alternate pitting. Fiber-tracheids and libriform wood fibers prevail, as do homogeneous rays. In other words, the "Amentiferae" are rather highly specialized from the standpoint of wood anatomy (TIPPO, 1938). Then, when it is recalled that EAMES (1929) and his students (FISHER, 1928; BECHTEL, 1921; ABBE, 1935; MANNING, 1938, 1940; BOOTHROYD, 1930) have published a series of papers on the floral anatomy of the "Amentiferae" which indicate that the *Salicaceae, Urticales, Betulaceae, Juglandaceae,* and *Platanaceae* possess highly specialized flowers, having undergone extreme reduction through the loss of sepals, petals, stamens, carpels, ovules, etc., we can say that as far as anatomy is concerned there is little to recommend the "Amentiferae" as a primitive group of Angiosperms. On the contrary, the available evidence (TIPPO, 1938) indicates that some of the "Amentiferae", at least the *Casuarinales, Fagales,* and *Urticales,* are derivatives of the *Hamamelidaceae,* which, in turn, are derivatives of the *Magnoliales.*

Wood anatomy has assisted in the phylogenetical placement of other groups. For example, the *Rhoipteleaceae* have been placed in the *Urticales* by some students of the family, and in the *Juglandales* by others. WITHNER (1941) investigated the anatomy of the family, and concluded that they belong to the *Juglandales* for the *Rhoipteleaceae* have scalariform perforation plates, which are also present in the *Juglandales* but are lacking in the *Urticales.* The aromatic glands and the pinnately compound leaves of the *Rhoipteleaceae* constitute further evidence that this family belongs with the *Juglandales.*

The *Eucommiaceae* have been placed in the *Hamamelidales,* although some systematists have suggested that the family should be classified with the *Urticales.* The anatomy of these groups has been investigated (TIPPO, 1940), and the conclusion has been reached that the family should be assigned to the *Urticales.* The *Eucommiaceae* have vessel elements with simple perforation plates, and latex; characters found in the *Urticales,* but absent in the *Hamamelidales.*

VESTAL (1937, 1940) investigated the families assembled by

ENGLER in the *Parietales,* and found that WETTSTEIN'S division of this heterogeneous order into the *Parietales* and the *Guttiferales* is sound on the basis of the anatomical evidence.

Employing the methods outlined, HEIMSCH (1942), in an extensive study of the comparative anatomy of the wood of the *Gruinales* and the *Terebinthales,* concluded that the *Burseraceae, Meliaceae, Sapindaceae, Rutaceae, Simarubaceae,* and *Anacardiaceae* constitute, on the basis of their wood structure, a phyletic unit. Therefore, the classification of ENGLER which places some of these families in the *Geraniales* and others in the *Sapindales* is not supported. Support, however, is given to WETTSTEIN who places the families in the *Terebinthales,* and to HUTCHINSON, who puts them in the *Pinnatae.* HEIMSCH concluded further that the *Julianiaceae* are close to the *Anacardiaceae,* but that the *Juglandaceae* are not closely related to either of these two groups. He also suggested that the *Simarubaceae* may not be a natural family since there is extreme diversity in the xylem.

The best illustration of the anatomical method with its harmonization of the evidences from floral morphology, cytology, paleobotany, and other fields is offered by the cooperative investigations of BAILEY, HOWARD, SMITH, and NAST. The following conclusions have been reached: The newly described genus *Degeneria* belongs to a separate family, the *Degeneriaceae,* closely related to the *Magnoliaceae.* The *Degeneriaceae, Himantandraceae,* and *Magnoliaceae* (*sensu stricto*) are closely related, while the *Winteraceae* show only remote relationship to the *Magnoliaceae,* and therefore the genera of the *Winteraceae* should not be placed in the *Magnoliaceae. Trochodendron* and *Tetracentron* are very similar structurally, but these two genera are quite different from the *Winteraceae* and should be removed from that family. *Illicium,* which has vessels, should be divorced from the vessel-less *Winteraceae* and should be classified in a different family. *Euptelea* exhibits no significant similarities to *Tetracentron* and *Trochodendron* and should not be associated with these genera.

BAILEY (1944), who has been the leader in this field for three decades, is of the opinion that these lines of structural modification are now so reliably established that they are to be reckoned with in considering any phylogenetic theories pertaining to the Angiosperms. He states that "the fact that structurally primitive angiosperms had scalariformly pitted tracheids, from which vessels originated, rules out any possibility of deriving the angiosperms from the *Gnetales* or other known representatives of the higher gymnosperms. The *Ginkgoales, Coniferales,* and *Gnetales* are characterized by having a highly specialized and peculiar type of primary xylem which is entirely unlike that of other known vascular plants with the possible exception of the *Ophioglossales*." ANDREWS (1940) in this work on the Pteridosperms, refrained from speculating on the phylogenetic connection between this group and the Dicotyledons, because the former lack scalariform tracheids in the secondary wood.

DADSWELL (1939) and RECORD (1934, 1935) have both cited numerous additional examples of the contributions which the study of anatomy has made to classification. But perhaps enough has been said to reveal that in the groups investigated considerable light has been thrown on the phylogenetic problems involved. It is to be hoped that the work will continue until all the woody groups of the Dicotyledons have been re-examined in the light of these salient lines of anatomical evolution. It is also hoped that similar series will be worked out for other parts of the vegetative body, such as the phloem—where some progress has been made with the types of sieve-tube cells—the root, the leaf, the primary body, and other parts. Indeed, further improvement and refinement of our knowledge of some of the sequences of specialization in the secondary xylem itself would be helpful in future investigations. For example, whereas we know that the diffuse arrangement of wood parenchyma is more primitive than the various aggregate configurations, we are in ignorance with respect to the exact phylogenetic relationships among the apotracheal and paratracheal types. The same situation prevails in the case of the several types of vessel distribution.

The next logical development which may be expected in this field is a series of investigations of the herbaceous Dicotyledons, whose purpose will be not only to uncover new phylogenetic sequences, but to extend the lines of specialization already established into this relatively virgin territory. There is every reason to suppose that the trends already defined will be found to prevail in the secondary wood of the herbs, and there is also some basis for the belief that similar sequences will be unearthed in the primary xylem. BAILEY (1944), for example, has recently shown that the evolutionary development of the vessel elements in the primary xylem parallels the development of these structures in the secondary xylem.

For more details and for references, *see* The American Midland Naturalist 36: 362-372, 1946.

CARPELS AND OVULES

by THEODOR JUST
(Chicago Natural History Museum)

The word *carpel* is a descriptive term applied only to the megasporophyll of the angiosperms. As carpels are always closed, the seeds are concealed by them. This is the most important character distinguishing the angiosperms from the gymnosperms, whose seeds are exposed. The carpels of a flower are referred to as its *pistil,* or pistils. Together with the stamens they constitute the essential organs of the flower. Being the innermost organs, they terminate the axis (*torus* or *receptacle*).

Three main types of flowers are customarily distinguished on the basis of position of the essential as well as accessory organs. In the first, the other floral organs, *e.g.,* stamens, petals, and sepals, are inserted below the carpels, making the flower *hypogynous* and the gynoecium *superior;* if the floral organs are found on the rim of the saucer- or cup-shaped stem tips, the flowers are said to be *perigynous,* and the pistils are *half-inferior;* if the receptacle is deeply depressed like a cup, closely enveloping the pistil, and the floral organs are actually closer in position to the gynoecium than in the previous type, the flower is *epigynous,* and the gynoecium is *inferior.* As adnation between the receptacle and pistil is common in this type, the constituent parts of inferior gynoecia are often difficult to discern without anatomical analysis.

Pistils may be *simple,* consisting of a single carpel (*Ranunculus, Papilionaceae*) and as such *apocarpous* (1 to many), or *compound,* also known as *syncarpous,* if made up of two or more carpels. Compound pistils are usually the result of infolding and/or fusing of the margins of several carpels or both. Typically, carpels are folded along the *dorsal suture* (mid-rib) on the abaxial side and fused along the *ventral suture* on the adaxial side.

Ordinarily pistils consist of three main parts: 1) *ovary,* the lower flask-shaped portion, containing the ovules; 2) *style,* the narrow, neck-like sterile extension made up of free or fused carpels, traversed by growing pollen tubes; 3) *stigma,* the receptive organ, mostly terminal and spherical, though often of different position and structure, consisting of free or fused ends of the carpels and lined with viscous, papillate or hairy surfaces on which pollen grains land and germinate.

Syncarpous gynoecia are enclosed by an outer wall and subdivided by partitions into special cavities. These walls usually represent the united sides of two cohering carpels (*true* dissepiments), or they may be outgrowths of the mid-ribs or other parts of the carpels (*false* dissepiments).

The region bearing the ovules is commonly, though not very aptly, known as *placenta.* Placentation is a term used to indicate the arrangement of ovules in the ovary. The following types are commonly distinguished: in regard to the ovary, ovules may be (a) *parietal,* located on the walls, or *central,* located in the center; central ovules may be *apical* or *basilar* (also known as *free central*); in regard to the carpels themselves ovules may be (b) *marginal,* if growing near the margins of the carpels, or *laminal,* if situated on the inner surface of the carpels, or *axile* (*central*), if found in the center of the ovary.

The ovules may be *sessile* or *stalked,* if borne on a funicle. The latter sometimes gives rise to an *aril* or *strophiole,* a small protuberance appearing on the seed, or a *raphe,* extending in the seed for a certain distance along the line of contact between the funicle and the ovule. Dicotyledonous ovules are covered either by one or two *integuments, e.g.,* they may be *unitegmic* or *bitegmic.* The presence of two integuments, regarded as the more primitive condition, is characteristic of most *Dialypetalae* and many *Monochlamydeae.* One integument is found in most *Sympetalae, Betulaceae, Juglandaceae* and *Umbelliferae.* This condition is the result of fusion of two integuments or the loss of one of them. Integuments are absent in parasitic families, such as *Santalaceae.* The two integuments enclose the ovule proper, leaving a small opening at the tip, the so-called *micropyle,* through which the pollen tube enters in most cases. The opening of the outer integument is known as *exostome,* whereas that of the inner integument is known as the *endostome.* In some seeds the margin of the exostome grows into a visible protuberance, called *caruncle,* or may be otherwise modified. In the *Euphorbiaceae,* the placenta develops a peculiar outgrowth, the *obturator,* which covers the micropyle, until the pollen grains land, and disappears completely after fertilization. The region opposite the micropyle is called the *chalaza,* marking the point of insertion of the ovule on its funicle or the floral axis. The interior of the ovule is occupied by the *nucellus,* which in turn contains the *embryo sac.*

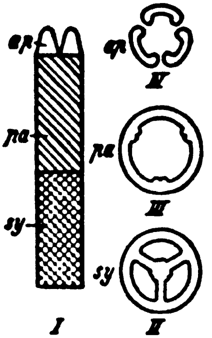
Ovules may assume various positions within the ovary. They may be *erect* (*orthotropous* or *atropous*), *horizontal, ascending* or *pendulous,* or *suspended* (*inverted* or *anatropous*). Half-inverted ovules are known as *amphitropous,* whereas ovules with bent nucelli are called *campylotropous.*

Styles are generally best developed in members of the *Sympetalae* and are often either filiform, subulate, clavate, petaloideous, plumose, or flat. In position they may be terminal or apical, lateral, or even basilar. The development and nature of the style is reflected in the shape and dimensions of the stigma. In some groups, special mechanisms for transmitting pollen masses are available, as for instance in the *Asclepiadaceae.*

The interpretation of the carpel, and of the flower as a whole, is one of the great morphological problems. Most of the older and newer views have been summarized by ARBER (1937), DOUGLAS (1944), JOSHI (1947), WILSON and JUST (1939), JUST (1948), and need not be detailed here. The crux of these discussions is whether or not the carpel is equivalent to a metamorphosed (folded) foliar structure (sporophyll) and ultimately appendicular in origin, axial by nature, an organ sui generis, or entirely nonexistent. At present most botanists are hesitant to abandon the classical view of the foliar nature of the carpel, as its modernized version still offers the best interpretation. The most notable improvements were made by EAMES and his associates with their fundamental contributions to floral anatomy and by TROLL and his school, whose views have been called *"Gestalt"* morphology (ARBER 1937), or, because of the emphasis on comparison as the principal method, the typological approach (WILSON and JUST 1939).

The ascidiform structure of carpels, first postulated by CELAKOVSKY in 1876, was confirmed by TROLL in his studies on peltate leaves. According to this view, carpels are regarded as metamorphosed foliar organs which at least begin their development as peltate structures, though they often lose this appearance later. Carpels may either be manifestly peltate, as in *Anemone, Thalictrum, Rosaceae,* etc., or *sub-peltate,* if their primordia alone are peltate as in *Delphinium, Aconitum, Aquilegia,* etc., or *epeltate,* if they show no sign of peltation at any stage.

Peltate carpels have long unifacial stalks and ascidiform laminae, whose free margins are lined with stigmatic papillae. Their



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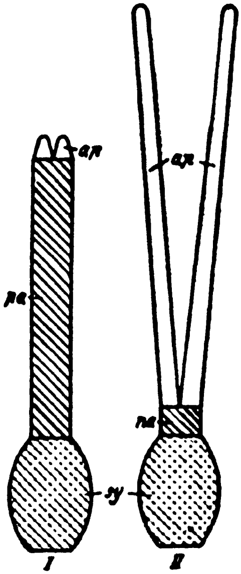

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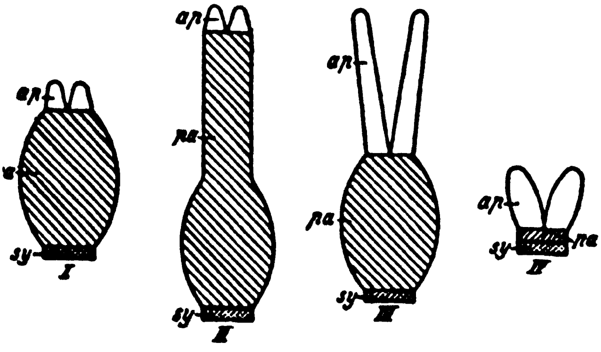

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Fig. 1. I. Typical structure of coenocarpous gynoecium. II-IV. Cross sections through syncarpic base (sy), paracarpic (pa), and apocarpic (ap) regions. — Fig. 2. I. Diagram of syncarpous gynoecium. II. Gynoecium of *Colchicum* with stylodia. — Fig. 3. I. Diagram of paracarpous gynoecium. II. Gynoecium of *Viola*. III. Gynoecium of *Passiflora*. IV. Pseudo-apocarpous gynoecium of *Caylusea canescens*. — ap: apocarpous; pa: paracarpous; sy: syncarpous. — All figures *after* Troll.

early development simulates that of peltate leaves in that the upper part of the lamina appears first without visible signs of peltation. But as the stalk appears, the transition zone between it and the lamina produces an expansion, the so-called *cross zone.* The ascidium of the carpel develops from the lamina and the cross zone.

Contrary to the customary application of the term style to all structures between the ovary and stigma, it should be used only for the elongated part of a coenocarpous gynoecium, *i.e.,* its more or less well differentiated, sterile, paracarpous region adapted to transmitting pollen tubes. On the other hand, separate branches should be called *stylar branches, stigmatic branches,* or simply *stylodia.* Functionally the whole region between ovary and stigma is best regarded as *pollen tube transmitter.* In many cases the carpels making up a style surround a canal, *transmitting tract,* often filled with *transmitting tissue* for transmitting pollen tubes.

Unlike the style, a stylodium is a simple structure being the free end of a carpel bearing stigmas. *Pseudostyles* occur only in monomerous gynoecia and often resemble real styles (*Mirabilis*).

Three kinds of pollen tube transmitters can be recognized: 1) *open,* with the canal lined by a simple epidermis in place of a special transmitting tissue, as in the *Aristolochiaceae, Ericaceae, Papaveraceae,* etc., 2) *half-closed,* with the canal surrounded by transmitting tissue as in the *Cactaceae, Boraginaceae,* etc., and 3) *closed* or *solid,* either with the canal completely filled by transmitting tissue as in the *Orchidaceae* and in most apocarpous gynoecia with stylodia, or without specialized transmitting tissue as in *Salix.*

The great variety of possible modifications can readily be illustrated by some examples. If the tips of the styles and stylodia are enlarged or otherwise modified and the papillae densely aggregated as in *Ipomoea, Apocynaceae, Asclepiadaceae,* etc., these structures are termed *stigmatic heads.* In some *Papaveraceae* stigmas are borne directly on the ovaries since styles and stylodia are lacking. In other forms the placenta even may produce outgrowths functioning as stigmas, *placental stigmas,* as in *Eschscholtzia, Glaucium,* etc. The peltate expansion of the style in *Sarracenia* functions as a collecting apparatus for pollen.

By the addition of certain types the classification of gynoecia was emended as follows: 1) *apocarpous,* and 2) *coenocarpous,* including a) *syncarpous* s. str., restricted to plurilocular gynoecia with central placentation, and b) *paracarpous,* representing unilocular coenocarpous gynoecia with parietal, basal or central placentation. The underlying assumption is that all coenocarpous gynoecia are based on a common structural plan regardless of the quantitative variations of its constituent parts.

A syncarpous gynoecium consists of three regions: 1) *syncarpic,* or fertile base, 2) *paracarpic,* represented by the style or stylar branches, and 3) *apocarpic,* or stigmatic region (*see* figure below). Paracarpous gynoecia can be derived from syncarpous ones by assuming that the syncarpic base remains small and relatively unimportant, while the paracarpic region becomes fertile. This view is substantiated by the number of transitional cases known to link paracarpous gynoecia with a recognizable syncarpic base with those lacking such. The frequent absence of styles in such families as the *Cruciferae, Capparidaceae, Resedaceae,* etc., all having paracarpous gynoecia, is attributable to the presence of a rudimentary syncarpic base and the transfer of the fertile zone to the paracarpic region. Frequently other structures are substituted for styles, namely 1) *gynophore,* a prolonged internode interpolated below the gynoecium (*Capparis*), 2) stylar branches (*Passiflora*), or 3) an elongated, but partially sterile, paracarpic region as in *Viola.*

Certain difficult cases have been re-studied and are now interpreted as follows. A *pseudo-apocarpous* gynoecium is characterized by greatly reduced syncarpic and paracarpic regions and free apocarpous ends of the carpels, as found in *Resedaceae,* whereas apocarpous gynoecia are composed of free carpels. A *pseudo-coenocarpous* gynoecium, as found in *Nigella, Pomoideae,* and *Monocotyledones,* is apocarpous in plan, since its carpels are united by the intercalary growth of the axis. If the inferior gynoecia of several flowers fuse, the product simulates a single pistil and is termed a *syngynium,* as in *Lonicera* spp. A *pseudo-monomerous* gynoecium resembles a single carpel, though it is actually coenocarpous in structure and apparently the result of reduction from more complex conditions. Two or more carpels are involved, one of which is fertile and fully developed. The position of the fertile and incompletely developed carpels reflects the symmetry of the flower, as in *Globulariaceae, Phrymaceae,* and *Plantaginaceae* (*Litorella, Bougueria*). A gradual transition from dimerous to pseudo-monomerous gynoecia can be traced in the *Urticaceae.* Pseudo-monomorous gynoecia of a dimerous plan are found in the *Thymelaeaceae, Cornaceae, Dipsacaceae,* etc., whereas such of a trimerous or polymerous plan are known from *Valerianaceae, Lauraceae, Chrysobalanaceae,* etc. Pseudo-monomerous gynoecia are different from truly monomerous ones, as found in *Ranales, Rosales,* and *Monocotyledones,* whose solid carpel represents the final stage of reduction.

EMBRYOLOGY

by HERBERT F. COPELAND
(Sacramento College)

The embryo begins after fertilization, but the word embryology is usually taken to include also the development of the pollen grain and of the ovule before fertilization.

Pollen:—A pollen sac is a eusporangiate sporangium, much like that of *Ophioglossum.* Pollen mother cells are surrounded by nutritive cells called tapetum. One type of tapetum called secretion tapetum shrivels to nothing as the pollen cells grow; in the type called amoeboid tapetum the cells enlarge and become confluent. The nuclei of the pollen grains undergo meiosis, producing four nuclei, with chromosome number changed from diploid to haploid. Usually the four pollen grains are formed by simultaneous constriction, "simultaneous division"; sometimes there is cell plate formation after each division of the nucleus, "successive division". The pollen grain nucleus divides twice, forming a tube nucleus and two sperm nuclei. The second division may be delayed: at pollination the grains may include either three nuclei or two.

Ovule:—The young ovule is the nucellus covered by one or two integuments; two in all families regarded as primitive. The nucellus is a eusporangiate sporangium the same as the pollen sac, but with no tapetum or endothecium. Crassinucellate ovules have the megaspore mother cell or cells more or less embedded. The tenuinucellate ovule has a single megaspore mother cell covered by a nucellus of a single layer of cells, this is a derived type occurring in most *Sympetalae,* as well as in various other dicots.

Embryo Sac:—In the normal type, one megaspore mother cell divides, forming four megaspores; only one of these, usually the innermost, enlarges and divides, producing eight nuclei in seven cells, namely an egg and two synergids at the micropylar end, a large endosperm mother cell with two nuclei in the middle, and three small antipodal cells at the chalazal end. The whole is the female gametophyte or embryo sac, homologous with the endosperm in cycads and conifers. This normal type occurs in the overwhelming majority of angiosperm families, lowest and highest, but there are several derived types.

Fertilization:—Normally the pollen tube enters the ovule through the micropyle and one of the two sperm nuclei fertilizes the egg. In *Fagaceae, Casuarinaceae* and a number of other families fertilization occurs through the chalaza.

Endosperm:—The second sperm nucleus unites, at least in most cases, with both the nuclei in the endosperm mother cell, from which the endosperm develops. This phenomenon is called double fertilization. The endosperm thus developed is peculiar to angiosperms, though a similar phenomenon has been reported in the *Gnetales.* In the supposedly primitive angiosperms the endosperm nucleus divides repeatedly before cell division, "nuclear endosperm"; in others each nuclear division is followed by cell division, "cellular endosperm." The endosperm may or may not produce outgrowths called haustoria, often significant in classification. In *Ericales* the two first cell divisions in the endosperm are transverse and haustoria are produced. In *Polemoniales* and related groups the first division is often transverse, the second longitudinal, after which haustoria are formed; this is also the development in *Callitrichaceae.* In *Rubiales* and *Asterales* the first division is often longitudinal and no haustoria are formed.

The development of the embryo is embryology in the strict sense. In most angiosperms there is produced first a suspensor, with the embryo at the end*.

The microscopic reproductive characters assure us of the unity of the group of angiosperms and distinguish it sharply from all other groups. Dicots and monocots are separated by a genuinely embryological character, the embryo. But these groups are not distinguished by other microsopic reproductive features, such as mark orders, families and subdivisions of families. One feels assured of the validity of such groups when they are thus confirmed.

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*MAHESHWARI (Bot. Rev., Jan. 1950) agrees with SCHNARF that characters of the male gametophyte are equal to such as ovule structure, number of floral parts, etc. Only the sum of *all* characters can lead to a clear and correct picture of relationships.

CYTOTAXONOMY

by J. HERBERT TAYLOR
(University of Tennessee)

To achieve a classification that represents natural relationships and is at the same time useful in indexing plants, modern taxonomy must make use of many varied lines of evidence. In recent years cytology has played an increasingly important role. For convenience in discussion, the kinds of evidence may be considered under the headings of chromosome numbers, chromosome morphology, chromosome behavior as observed during meiosis, and aberrant forms of reproduction (SHARP, 1943), but these considerations are not isolated in their use.

In looking over a list of the chromosome numbers among the species of many groups, one is struck by the frequent recurrence of base numbers or multiples of these numbers. The significance of these diploids and polyploids in interpreting relationships and phylogenetic origins is the field in which the cyto-taxonomist has at present the most evidence for major generalizations. No criterion can be given for the significance of polyploidy in distinguishing groups. Each case is different and must be considered individually. Sometimes diploids and polyploids within a group may be very similar taxonomically and are ordinarily included in one species. In other cases they may be different species or even different genera. The value of chromosome numbers in classification, whether polyploidy or any other type of variation occurs, remains of value in understanding the whole pattern of a group when considered with all other evidence. Its peculiar importance as compared with other types of evidence is that in many cases the direction of evolution may be more clearly indicated.

Differences in chromosome morphology that are most useful to the cyto-taxonomist are differences in size (length and diameter); the occurrence of recognizable constrictions that correspond to the centromere (spindle attachment region), nucleolar organizer or any other constant structures; the presence of satellites on some chromosomes of the complement, and the presence of knobs such as occur in *Zea mays* and its relatives. Chromosomes may differ in number, length, and position of constrictions.

Some of the variations in chromosome structure not observable during mitosis may be studied during meiosis, particularly in hybrids. In general, synapsis of chromosomes is dependent on homology or genic similarity and the differences due to inversions, deletions, duplications of parts or whole chromosome, and translocations of parts of chromosomes often become apparent.

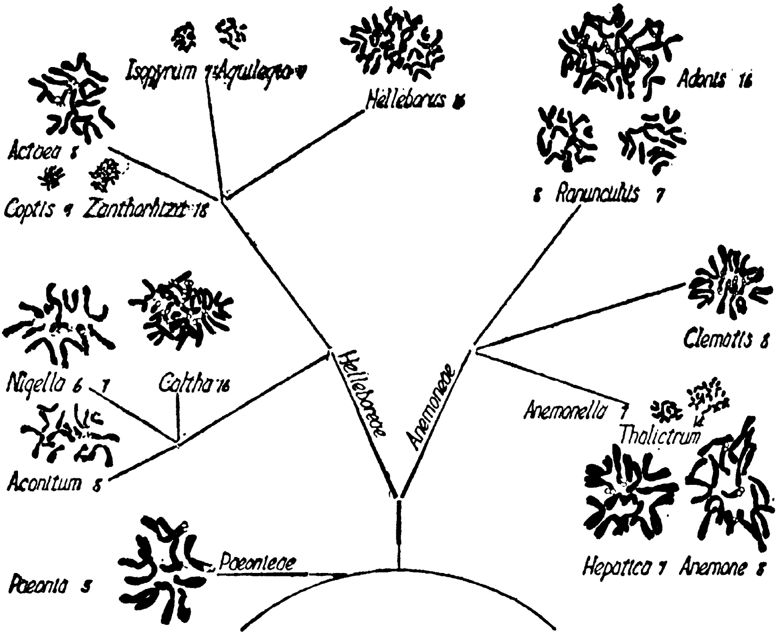
Knowledge of the distribution of apomictic forms of reproduction, obligate or facultative, within a taxonomic group is useful to an understanding of its evolution and classification.

A number of investigations have been useful in understanding the distribution, variation and evolution within a species. *Sedum pulchellum* was found to occur in three forms, diploid (2n=22), tetraploid and hexaploid (BALDWIN, 1943). The range of the species is from Missouri to Texas and from southern Illinois to Alabama and Georgia. West of the Mississippi and in the southern part of the range only the diploid was found. The tetraploid was found in the northern range east of the Mississippi. Where the range of diploid and tetraploid overlap in Tennessee the hexaploid also occurred. The three races differ morphologically, but it is doubtful if all three types can be consistently recognized in the field. However, with this understanding of distribution and variation the taxonomist is better able to evaluate the position of this species.

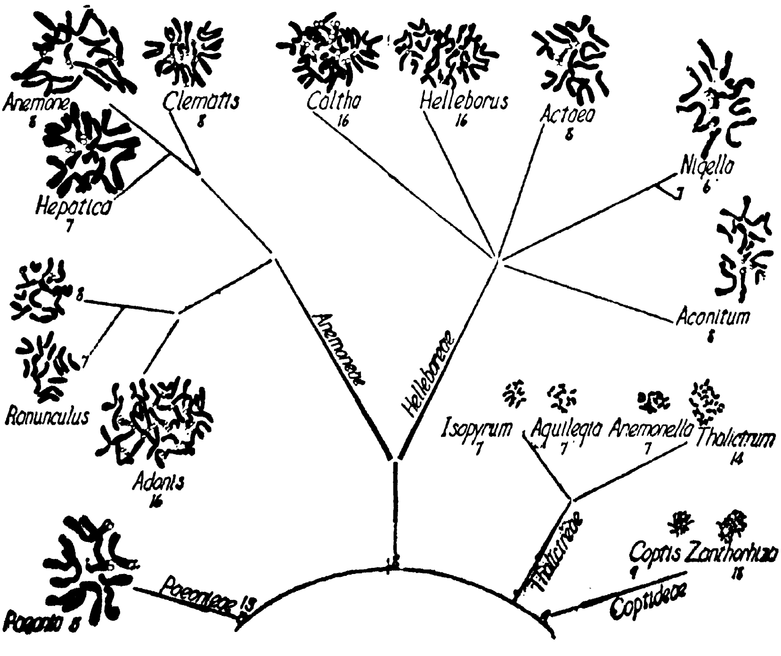
The analysis of the species of the genus *Tradescantia* by ANDERSON and SAX (1936) has proven most useful for those interested in a more complete picture of this complex group. BABCOCK (1943) and his co-workers have shown what could be done by relating systematics, cytology and genetics in studying the world pattern of evolution, present distribution and taxonomic status of the genus, *Crepis*.

Several attempts have been made to analyze whole families on the basis of cytology and the taxonomic data at hand. In larger groups the data becomes more difficult to collect and few attempts have been made to generalize on the cytological implications of relationships between families.

The value of cytological evidence in elucidating cases of parallel evolution at the level of family groups is shown by the work of McKELVEY and SAX (1933). *Yucca* has a superior ovary which

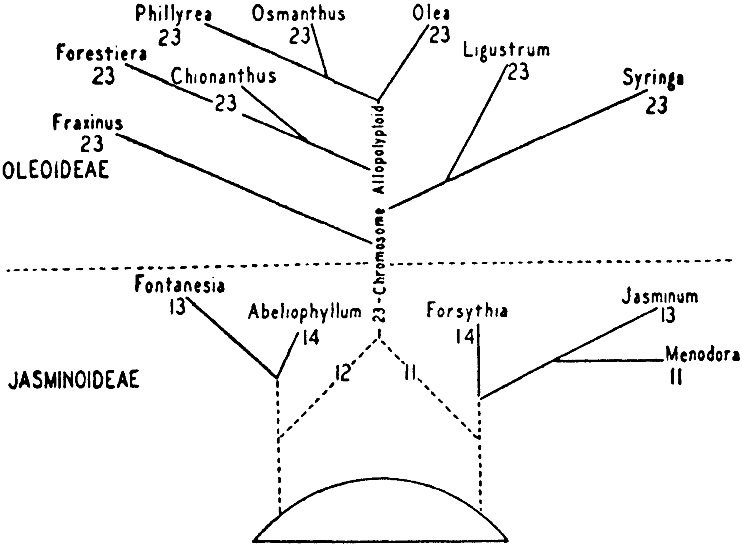


Charts illustrating phylogenetic and taxonomic relationship in the *Ranunculaceae.* Above, the genera are arranged by tribes according to the Engler system, and below, by the new classification suggested on the basis of chromosome type, chromosome number and type of fruit (*after* W. C. GREGORY).



places it in the *Liliaceae,* whereas *Agave* is included in the *Amaryllidaceae* on the basis of an inferior ovary. Examination of the number and morphology of chromosomes indicates a closer relationship between the two genera, which also becomes apparent when many of the other morphological characters are compared.

A similar situation was discovered in the *Ranunculaceae* where the genera were grouped on the basis of follicular versus achene fruits. Such a classification places together genera which look very different vegetatively and behave differently in cultivation



Phylogenetic chart of *Oleaceae*

(Langlet, 1932 and Gregory, 1941). Efforts of systematists to find a method of clearing up the difficulties had not succeeded until cytological work showed the situation to be a matter of parallel fruit development in two very different groups of the *Ranunculaceae.* Using the data from chromosome-type, basic numbers, and type of fruit, Gregory was able to rearrange the family into much more natural groups, as shown on p. 23.

The *Oleaceae* is another family in which cytological data pointed out changes that can also be substantiated with additional morphological evidence (Taylor, 1945). The family has been divided into the *Oleoideae* and the *Jasminoideae* on the basis of the point of attachment of the ovules in the locules of the ovary and the presence or absence of a constriction through the apex of the fruit. While these characteristics are fairly constant for genera, there are many exceptions when it is used for a division of the family. If chromosome number is used as a criterion along with morphology the genera fall into groups that harmonize all of the data at hand. The rearrangement of the genera in the two subfamilies is shown on p. 23. It will be noticed that the base number 23 is constant throughout the diverse and widely distributed subfamily, *Oleoideae,* as visualized in this classification. Evidence from the study of the family as a whole indicates that this group's point of departure in evolution was an allopolyploid type (TAYLOR, 1945), this group being monophyletic, while the subfamily, *Jasminoideae,* probably contains the end branches of a phyletic tree that may not have converged within the family group. If ancestral types for the *Oleoideae* still exist, one is forced to look to the other members of the order for them. This subfamily is the largest reported group without near relatives for which a single allopolyploid origin is indicated.

The *Magnoliales* show a tendency to split into two groups, a 14-chromosome series and a 19-chromosome series, although HUTCHINSON's classification has divided the order into five families with these two groups of genera scattered among them. Additional morphological evidence that has seldom been used supports the relations indicated by cytology (WHITAKER, 1933).

The use of cyto-taxonomic data to assist in the arrangement of families within orders and to indicate relations between orders is a project for the future. With the increasing store of information that leads to an analysis of trends within large family groups and generalizations using the best information from all fields of endeavor, we can look forward to a time when these building blocks begin to fall together in more natural patterns. There is an increasing need for the use of cytological data by workers who have broad taxonomic concepts, or a closer collaboration between workers who have extensive knowledge in the separate fields. Another need is the digestion and sifting of the unwieldy data that has accumulated in the field of cytotaxonomy. The cataloging of chromosome numbers has been a step in this direction (GAISER, TISCHLER; and DARLINGTON and JANAKI, 1945), but to be usable in analyzing larger groups each unit must be studied critically with tendencies noted and previous work evaluated. With these discrete working units we can begin to fit the pieces together in their proper sequence.

PLANT GEOGRAPHY

by W. H. Camp

(The Academy of Natural Sciences of Philadelphia)

Two generalized types of plant geography may be recognized. One is descriptive—it tells us of the types and kinds of plants which occur throughout the various regions of the world and in different climatic zones, both latitudinal and altitudinal. The other is dynamic—it deals with the history of natural plant populations, their origin and dispersal. It is this latter and more recently developed type of plant geography which is closely related to the systematics of plants.

When discussing dispersal it has been the custom of plant geographers to outline the total-area distribution of groups. Methods for the study and analysis of the dispersal patterns of plants (together with extensive bibliographies on related subjects) may be found in the works of such writers as Cain, Good, Raup, and Wulff. A somewhat different method of analysis has been used by the present writer in a discussion of distributional problems. This type of investigation demonstrates the close correlation which often exists between a broad interpretation of the geographical distributions of the various members of a group and its phyletodispersal pattern. This can lead directly to a clarification of its basic systematics.

The *Violaceae,* for example, is essentially world-wide in distribution. Surrounded on every side by the multitudinous species of *Viola* in north temperate regions, we sometimes forget that the other genera of the family are primarily tropical. In the lowlands of South America one sees the primitive, actinomorphic-flowered members of the family as fairly good sized forest trees; shrubs and lianoid scramblers also are found. As one ascends the slopes of the Andes, the various life forms and flower types begin to be more familiar in appearance until, finally, at the higher elevations where seasonal frost and snow are to be expected, one encounters things very similar to the plants of our own northern woodlands and pastures. While making such a transect—both in altitude and through the genera of the family on different evolutionary levels—one scarcely can come to any but the following conclusions: That it was in South America that the family underwent its primary development and, also, that it was there that *Viola,* the most advanced genus of the group, was evolutionarily pre-conditioned for its subsequent migration into the Northern Hemisphere and elsewhere.

The *Capparidaceae* and *Cruciferae* usually are closely associated in systematic texts. The *Capparidaceae* is replete with arborescent, woody forms which are tropical in distribution; yet one encounters herbaceous cruciferoid members of the Caper Family. In contrast, the *Cruciferae* is mainly herbaceous and temperate; yet one also encounters capparoid forms which have been placed in the Mustard Family. On the basis of a series of morphological characters, one arrives at the conclusion that the Capparidaceae gave rise to the *Cruciferae,* for there is no good dividing line between them. This capparid-crucifer complex would be an excellent one in which to study evolutionary trends and geographical sequences for it runs the entire gamut of phyletic reductions and series of ecologically adjusted biotypes from many-stamened, arborescent tropical forms to few-stamened, ephemeral annuals of desert and arctic regions.

Similar studies at times lead to other types of conclusions. For example: The genus *Paeonia* has long been placed in the *Ranunculaceae;* however, as CORNER demonstrated (*cit. in* CAMP), a re-analysis of its floral morphology indicates that *Paeonia* has greater affinity with the *Dilleniaceae. Crossosoma,* a genus of our southwestern region, also is involved. When looked at from the viewpoint of their comparative distributions, it would appear that *Crossosoma* and *Paeonia* are the northern, essentially temperate relatives of the tropical and primarily Southern Hemisphere *Dilleniaceae,* both probably meriting recognition as derivative, monogeneric families. Similarly, one may wonder whether *Clematis* is not much more closely related to the similarly free-carpelled, often compound-leafed, mainly scandent, woody groups such as the *Lardizabalaceae* and *Sargentadoxaceae,* and probably even to the *Menispermaceae,* than to the otherwise essentially herbaceous eu-*Ranunculaceae.* The monocarpic, plumose fruit of *Clematis* is not a feature which has been patented by the *Ranunculaceae* for it appears in other groups.

In like fashion, one finds the *Escalloniaceae* (sometimes included with the *Saxifragaceae*) as a complex group wide-spread in the Southern Hemisphere. A probably related, but more advanced group, is composed of the currants and gooseberries (*Ribes* and *Grossularia*). Of these two, *Grossularia* is the more advanced and occurs only in the Northern Hemisphere; *Ribes,* although primarily northern, occurs also southward along the Andes to Patagonia. In the Andes are found obviously primitive species of *Ribes* which one has some difficulty distinguishing at first glance, both in the field and herbarium, from the ecologically associated, advanced members of the *Escalloniaceae.* Again, on the basis of the morphology of the various forms, one scarcely can avoid the conclusion that the lowland, tropical, and primitive superior-ovaried *Escalloniaceae* gave rise to its advanced partly-inferior-ovaried Andean forms and these, in turn to the associated inferior-ovaried members of *Ribes.* Gradually accumulating its own advanced members, *Ribes* then apparently migrated into the Northern Hemisphere where it produced the forms which developed further into the present genus *Grossularia.* Whether this closely linked chain of evolutionary development, each segment with its own set of subsidiary off-shoots, should remain in the *Saxifragaceae* (or even in the *Saxifragales*) is a question which can be settled only by further study. However, one might observe that certain evidences point to the likelihood that the primarily temperate eu-*Saxifragaceae* is not closely related to the foregoing but, as a separate phylad, may have developed from the same basic stock as the more tropical *Crassulaceae.*

Thus, in these and many other instances, one can discern a very close correlation between the development and phyletic advancement of a closely knit group and the often progressively wider geographic dispersal of its segregate members as they ventured from the tropics into temperate regions. Such findings demonstrate the need for a more careful analysis of the relation between the distributional geography, phylogeny, and systematics of plant groups.

This type of dynamic plant geography has further ramifications. As one examines the distributions of various groups one learns, for example, that about 95 genera of angiosperms occur in both South America and Africa and are found nowhere else; also that about 35 genera are confined to South America and the New Zealand-Australia region. These are only a small portion of the many known genera with other types of wide distributional disjunctions, their members often separated by vast expanses of open ocean. Various theories have been brought forth to account for such things, especially where plants of the Southern Hemisphere are concerned.

Some have sought to elucidate the cause of such disjunctions by citing what seemed to be examples of dispersal by means of winds and ocean currents. It cannot be denied that winds and ocean currents have been factors in the dispersal of certain types of plants. But winds cannot be used to explain the wide disjunctions in groups with heavy seed. Nor will they serve for the vast number of tropical disjuncts whose seed will not stand frost; long-distance transportation by winds would also demand that the progagules be lifted into the stratosphere where the temperatures are such that the dormant seeds of even many temperate-climate plants would be killed. And those who evoke ocean currents have failed to explain how those groups which are characteristic of (and limited to) mountainous areas made the journey. It is admitted that their disseminules might float down stream and ultimately reach the sea; there they could be carried across wide stretches of ocean by currents (although it is well known that the majority of such seed is neither adapted to floating nor is viable after long submersion, especially in sea water). Furthermore, in this over-simplified explanation, so far, we have not been told just how, after their long ocean voyage, such seed would be able to navigate up-stream against strong currents and over waterfalls to the highlands, the only place where they would find habitats ecologically suitable and where they could compete at all effectively with the flora already present and so become established. Other writers have advocated convergent evolution—the production of similar-appearing forms out of different ancestral stocks. This would necessitate a negation of the generally accepted laws of descent.

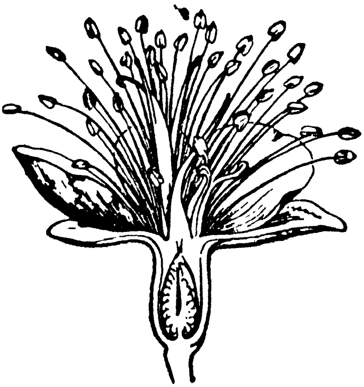
Realizing that the foregoing were not satisfactory explanations, still others have attempted to erect a series of "land bridges" over which members of these groups could have migrated. The theory is intriguing, but the geological facts offer little in the way of solid foundations for the necessary geo-architecture of all too many of these hypothetical bridges, especially where they are most sorely needed in the Southern Hemisphere. Others therefore, have supposed that the angiosperms originated in the northern Holarctic region and later migrated southward along the axes of the southward-projecting continental masses. This explanation would pre-suppose a later extinction of the northern members, leaving the ones now on the southern continents as disjunct relics of a former essentially world-wide distribution.

There is much to be said for this theory of a northern origin and examples of the fossil remains of evident warm-temperate and even tropical angiosperms north of the present Arctic Circle are presented as proof of it. Its proponents, however, have been unable to offer a satisfactory explanation of how such plants could have existed under arctic conditions; or even if the polar regions then were warmer, how they could have persisted under conditions of some months of darkness. Many of these appear to have been non-deciduous types, surprisingly "modern" in aspect, and it is indeed difficult imagining how they could have survived long periods without replenishing their dwindling food reserves. Plants do exist today in the high Arctic; but they are considerably specialized types. Certainly they are not large, megaphyllous forest trees with mesic life-forms.

Admitting these major objections, some have advocated the theory of a "wandering pole." Here again difficulties arise for, when the North Pole is theoretically so placed that it would have permitted subtropical or even temperate conditions near the present one, too often in another part of the world a contemporaneous fossil flora is found which would have been in the wrong climatic zone.

Another objection to a northern origin of the angiosperms is revealed when one associates the distribution patterns of the majority of groups with their phyletic patterns. Usually it appears as if there have been a series of phyletic segregations and subsequent migrations, in some groups originating in, and in others involving only the Southern Hemisphere. This has led an increasing number of students to lean toward the theory of "continental displacement"—wherein it is held that the continents once were much more closely connected than at present and that the plant groups common to them already had evolved at least their basic members before the continents drifted apart. At first the majority of geologists were unwilling to accept this theory; more recently even its most vigorous opponents have begun to admit that continents can shift their relative positions. It is quite likely that a careful review of plant geography in its more modern phases will shed considerable light on the problem of distance and direction of the displacement or drift; the mechanics of the phenomenon is a problem for the geologists.

At first glance, it may seem that paleogeography has little to do with plant systematics, that it might better be left entirely to the geologists. However, paleogeography and paleoclimatology are intimately connected with an interpretation of paleobotanical events and sequences; thus they become part of the whole problem of phylogeny, the mainspring of plant classification. It is therefore obvious that the newer phases of plant geography, ramifying as they do into geo-history and phyletics, are very closely related to basic plant systematics.

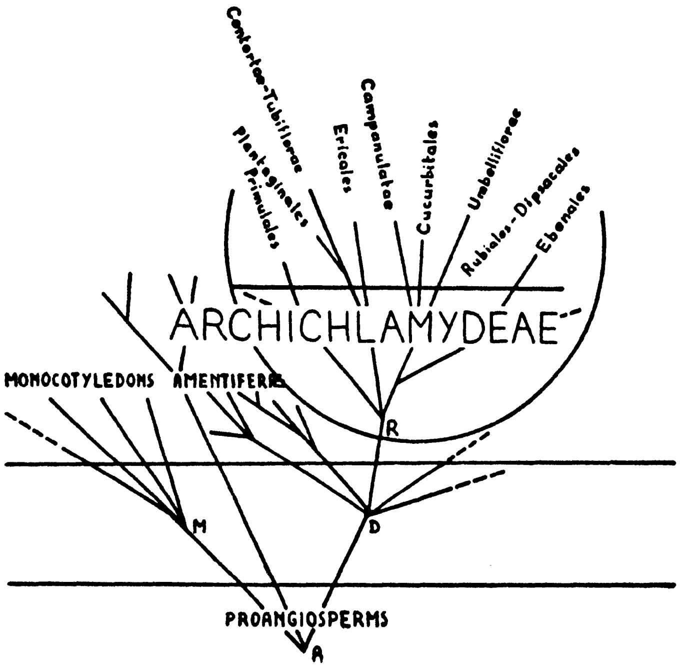


Part 2

CHARACTERS

of

DICOTYLEDONS



WERNHAM'S diagram, "showing possible lines of descent of the *Angiospermae* from a proangiospermous ancestor, A. M., ancestor of the Monocotyledons, D, of the Dicotyledons. The Sympetalae and their archichlamydeous ancestry are included in the circle, diverging from the Ranalian Common Ancestor, R. The lines are supposed to occupy all directions in space as may be necessary" (Redrawn *from* New Phytol. 11:385, 1912).

Plant affinities spread out in all directions like regions on a map.... a natural classification is the first and last aim of systematic botany, wrote LINNAEUS. The great lines of evolution of whole families lie outside the limits of experiments..., a repetition of their history is far beyond human powers, wrote DE VRIES, 1905. Living families run, so to speak, at right angles to the course of evolution (BENSON, 1921). The distinguishing factor of phylogeny versus taxonomy is time..., taxonomy is based on characters, phylogeny on changes in characters (LAM, 1938). Group concepts and lineage concepts are different. The terms natural and artificial classifications are misleading. One of the main difficulties is just this problem of what taxonomists are aiming at in classifying living things. (GILMOUR, 1940).

A number of botanists have outlined their views as to what are primitive and what are derived characters of angiosperms.

Stem:—With the lower groups of plants generally of smaller size than seed bearing plants it long seemed reasonable to consider herbaceous plants as more primitive than trees and shrubs. During the present century the opposite view has become widely accepted. Gymnosperms antedate angiosperms by long geological periods, yet they include no herbaceous forms. Sympetalae are generally considered more advanced than Polypetalae, and they have a much larger proportion of herbaceous forms. Among the many families which include both woody and herbaceous plants it is the herbs that usually have the more specialized floral characters. Many families include mostly woody plants in warm regions with a few herbs in temperate climates, while Arctic plants are nearly all herbaceous. It seems that the herbaceous condition is an adaptation to an unfavorable season, that may be either cold or dry. The change from a woody to an herbaceous stem must have occurred within many different families. Glacial periods may have had much to do with the spread of large herbaceous families. The evolution of herbs is likely to have been more rapid than that of woody plants because of the relatively small interval from seed to seed, says SINNOTT, 1916. Such considerations support others in changing the sequence of various families from that in the ENGLER system, such as by placing *Flacourtiaceae* before *Violaceae, Capparidaceae* before *Cruciferae, Passifloraceae* before *Cucurbitaceae, Sterculiaceae* before *Malvaceae,* and *Bignoniaceae* before *Scrophulariaceae.* But a few woody plants such as in *Berberidaceae* and in *Cucurbitaceae* may have been derived from herbaceous ancestors. And the earliest dicotyledons may have been small trees and shrubs rather than tall trees.

Leaf:—Leaves of ferns and higher plants are interpreted as flattened and fused branch systems. Ancestral conifers may have had broad leaves like those of *Ginkgo* and *Cordaites.* Leaves of ferns and pteridosperms have characters in common with those of cycads and cycadeoids. Did the ancestors of dicotyledons have fern-like leaves? Compound and also simple leaves occur in *Rutaceae, Oxalidaceae, Rosaceae, Leguminosae, Oleaceae* and other families, likewise in genera such as *Sorbus, Rhus, Acer, Fraxinus.* In some of these compound leaves seem to be the primitive condition. Have compound leaves generally preceded simple ones? Does the principle of reduction, so important in flowers, apply also to leaves? A number of other leaf characters such as their position and form, the branching of veins, the character of petiole and stipules, of the epidermis and hairs, are often similar in related genera and sometimes in families. The systematic value of the form of pubescence is great, said SOLEREDER. FLORIN has pointed out the difference in stomata in cycads and cycadeoids. Have they some importance in classifying dicotyledons? *Ranunculaceae, Berberidaceae, Cistaceae, Papaveraceae* and others have guard cells surrounded by ordinary epidermal cells. The *Rubiaceae* type occurs in *Annonaceae, Hamamelidaceae, Mimosaceae* and very many other families. *Cruciferae* have three subsidiary cells. In *Proteaceae, Casuarinaceae* and other desert plants the stomata are deeply sunken.

Inflorescence:—*Umbelliferae, Compositae, Boraginaceae,* the catkin-bearers and many other families have a more or less characteristic form of inflorescence. RICKETT, 1944, says the inflorescence may be older than the flower in its present form; he suggests it may be idle to speculate on the origin of inflorescences, since we know so little of the relationships of flowering plants. The presence of a terminal flower is not considered significant. Racemose and cymose types have readily changed from one to the other, as clearly explained by GOEBEL, 1931. RICKETT considers the simple dichasium to have the marks of a primitive type; by repetition of the branching a panicle-like dichasium is obtained. The raceme, spike, catkin, corymb, umbel and capitule are all specialized forms.

Flowers and Insects:—Wind pollination characterizes nearly all conifers and cycads; their fossil relatives *Cordaites* and pteridosperms were doubtless also wind pollinated. Wind pollination began perhaps two hundred million years before insect pollination; wind pollination in the Devonian, insect pollination in the Jurassic. By wind action great quantities of pollen are blown in all directions, but by insect action small quantities are brought directly from one plant to a similar one some distance away. Insect pollination was an all important improvement with very great consequences in the world of life. "The Secret of Nature Discovered in the Form and Fertilization of Flowers" by KRISTIAN KONRAD SPRENGEL, published in 1793, long remained nearly unnoticed. Very many facts about flowers can be explained only in connection with the activities of insects; such are their crowded parts, their colors and fragrance, zygomorphic and tubular corollas, corolla markings and hairs, the presence of nectar glands. The character of angiospermy itself is essentially a protection of ovules from insect visitors, as pointed out by ARBER and PARKIN in 1907. They suggest that angiosperm flowers may have come much earlier than the typical leaf of dicotyledons. Cycadeoids came in Triassic times, they had stamens and ovules on the same cone, a prerequisite for effective insect pollination.

Trilobites lived through Paleozoic times and vanished. Today live their smaller but innumerable relatives, copepods in water and insects on land. Early insects must have sought food from whatever sources were available, including pollen and ovules. Today insects such as dragon flies, grasshoppers and beetles occasionally visit flowers, but are not adapted for pollination. Short tongued bees and some flies are partly adapted, but long tongued bees and butterflies are especially adapted as flower pollinators. Bees have played the chief part in the evolution of flowers, wrote HERMANN MÜLLER in 1876. And flowers must have played a chief part in the evolution of bees and other pollinating insects. Forerunners of angiosperms needed something that insects could supply, forerunners of pollinating insects needed something plants could supply. From the time that mutual benefit resulted from their association, mutual selection played an increasing role; plants selected insects and insects selected plants, more plants adapted to insects meant more insects adapted to plants. As a result, during Cretaceous times angiosperms and pollinating insects spread over the earth.

A number of angiosperms have reverted to wind pollination. Among wind pollinated angiosperms are *Platanus, Liquidambar,* *Ulmus, Quercus, Betula, Juglans* and *Populus*, also herbaceous plants such as *Chenopodium, Amaranthus, Plantago, Ambrosia* and others. The flowers of these plants are small, greenish, without fragrance or nectar, with pollen and ovules nearly always in separate flowers. The staminate flowers are often in catkins, or the stamens have slender filaments; the pistillate flowers are relatively few in number, often with a single ovule, often with a feathery or broad lobed stigma. Many of these plants are referred to under the separate families.

Floral Anatomy:—According to EAMES, 1947, a flower anatomically is a determinate stem with appendages. The flower, in its conservatism, holds evidence of the ancestry and relationships of plants; anatomy holds still more evidence, hidden within the flower. Flowers in their vascular skeleton differ little from leafy stems. The pedicel and the receptacle have typical stem structure. Each of the appendages has traces like those of leaves. The vascular tissue usually has separate strands; it is often simple, broken only by the gaps of the traces. Anatomy usually reinforces commonly held views as to flowers. Sepals are bracts, with very few exceptions anatomically like the leaves of the same plant. Petals are usually like stamens, commonly with one trace. In the great majority of families petals are sterile stamens. Stamens usually have a single trace. The carpel is anatomically the most complex of floral organs, because it is a folded structure, also, being innermost, carpels are most affected by cohesion and adnation; the upfolding and fusion of carpels is evident from anatomy. The leaf of angiosperms has 1, 3, 5 or many traces, 3 is the common number and probably primitive. Carpels also have 1, 3, 5 or several traces, 3 the most common. The 1 trace carpel is usually an akene, derived from a 3-trace type. *Platanus* has 3-trace carpels, its pistil is an akene with the structure of a follicle, partly open. In *Waldsteinia* the akene is a small follicle with ovules reduced to one.

All stages of cohesion, adnation and reduction occur in many groups. The effects of cohesion on the vascular skeleton is clearly shown in the gamosepalous calyces in *Labiatae* and *Caryophyllaceae*. The corolla of *Compositae* shows various stages in the fusion of the lateral veins of the petals. Adnation is similar to cohesion. Bundles close to each other may become fused, the epipetalous stamen is an example. The inferior ovary is an extreme case of adnation. Reduction is seen in *Sambucus* which has 3 carpels, but has vascular supply for 2 others. *Primulaceae* have lost one staminate whorl, in *Lysimachia* 5 vestigial traces run to the position of the lost stamens. *Gaylussacia* has 10 carpels, *Vaccinium* has 5, plus 5 vestigial ones. *Ulmus* shows remnants of another perianth whorl and of another whorl of stamens.

Perianth:— Sepals are modified bracts, but petals are usually modified stamens. Sepals, petals, stamens, carpels appear in the flower bud, always in that order. Numerous, spirally arranged sepals, petals and stamens occur in *Nymphaeaceae* and *Cactaceae.* In part spiral arrangement of parts occurs chiefly in the *Magnolia* and *Cistus* Groups. These same groups have usually entirely separate sepals, otherwise somewhat connate sepals is the rule. Bracts outside the sepals occur in *Ranunculaceae, Malvaceae, Betulaceae, Caryophyllaceae* and many other families; in *Rosaceae* the double bracts are the stipules of the sepals, in bud as large as the sepals. Petals are separate in most families, but somewhat connate petals occur among many *Polypetalae.* That petals are usually modified stamens is especially clear in *Nymphaeaceae, Rosaceae* and *Tiliaceae.* In *Helleborus* the petals are modified sepals. In a few families, for example *Proteaceae, Casuarinaceae, Balanopsidaceae* and others it may be questionable if their ancestors ever had petals.

Stamens and Nectaries:—Stamens are more reduced than any other part of the flower, says Wilson, 1942; to consider them as modified leaves is not adequate, for they are reduced from a dichotomous branching system which existed before leaves were evolved; the filament is the basal part of the system, the connective represents modified subsidiary branches, to which the reflexed sporangia have become fused. In other words spore producing parts preceded the differentiation of stem and leaf; the anther is a synangium of four sporangia, far antedating flowers. Parkin, 1934, says short filaments and long anthers, as in magnolia, are primitive, likewise a projecting connective. Filaments connate at the base of petals are common; branching filaments, as in *Guttiferae, Tiliaceae, Bombacaceae, Euphorbiaceae, Myrtaceae* and *Symplocaceae,* are not common but very possibly primitive. The difference between centripetal and centrifugal development of stamens is very important, according to Corner, 1946.

Nectaries are important in floral evolution, says Brown, 1938. *Magnoliaceae, Dilleniaceae* and part of *Papaveraceae* have no nectar glands. In *Lauraceae* individual stamens have become nectaries. Those of *Passifloraceae* and *Cucurbitaceae* have many points in common. In *Theales* one group has a conspicuous disk around the ovary like *Polemoniales,* another group suggests *Caryophyllaceae.* Wilson (in correspondence) says nectaries are significant in phylogeny only when they represent vestigial floral parts, in other cases they are mere enations; the two types can be distinguished only by anatomical methods.

Possible lines of evolution of stamens seem to have been from spiral to cyclic arrangement, from several whorls to one, from many to few, from hypogynous insertion to perigynous or to epipetalous; stamen traces from three to one, filament from branching to single, from broad to narrow: connective, from projecting to not projecting; anther, from long to short; dehiscence, from longitudinal to apical.

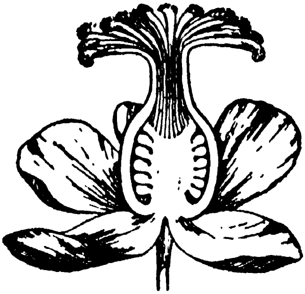
Pollen:—In pollen grains germinal characters are significant in phylogeny, says WODEHOUSE, 1935 and 1936; pollen should be moist to show details; the presence of spines is a conspicuous but not fundamental character. Primitive microspores were probably like fern spores, without pores or germinal furrow. In pteridosperms the pollen grains were very large, many celled; they probably left the microsporangia single celled and then developed in the pollen chamber near the ovule. The pollen of *Cordaites* and of cycadeoids has a single deep furrow, conifer pollen usually has one shallow furrow, flanked by bladders; however, *Cupressaceae* have neither furrows nor bladders. The pollen of cycadeoids can scarcely be distinguished from that of *Magnolia;* it has a single furrow, the same as cycads, *Nymphaea* and *Piper.* In *Winteraceae* the pollen grains develop in tetrads, so also in *Droseraceae, Nepenthaceae,* many *Ericaceae* and in *Salpiglossis;* in *Mimosaceae* they are often fused in a multiple of four. *Schisandra* has six furrows, three long ones meeting at one pole, three short ones not meeting; perhaps that is a transition to the ordinary three furrow pollen; that is the most common in dicotyledons, for example in *Rosaceae, Aquifoliaceae, Caprifoliaceae* and *Compositae. Cichoriaceae* have three furrows the same as *Compositae,* but have in addition an elaborate pattern often giving them an angular and distinct appearance. The abundant pollen of wind pollinated plants is dry and does not adhere to insects. *Juglandaceae* and *Betulaceae* have pores rather than furrows; *Chenopodiaceae* and *Amaranthaceae* have characteristic pores cut sharply into the exine; the number of pores varies.

Placentation:— It is possible that laminal or surface placentation such as occurs in *Winteraceae, Nymphaeaceae* and *Papaveraceae,* resembling some Pteridosperms, may be primitive. Common forms of placentation are parietal and axile. In buds parietal placentation often precedes axile, for example in *Philadelphus, Theobroma, Ilex* and many others. In bud all species of *Hypericum* have parietal placentation, in the adult flower some species have axile placentation. In *Shortia, Punica* and *Pyrola* the upper part of the ovary has parietal placentae, the lower part axile. The separate corolla tips of *Sympetalae,* relatively more prominent in the bud, are interpreted as representing ancestral separate petals. Are not placentae similar, are not axile placentae in most cases extended and more fully fused parietal placentae? But in some cases parietal placentation seems to be derived. Eames says parietal placentation is of two kinds, either syncarpy may have arisen while the carpels were still open, to some extent suggested by *Reseda,* or the septa may have been reduced or lost. Floral anatomy provides evidence of the history of placentation. Free central placentation has been derived from axile; basal placentation has come sometimes from free central, sometimes from parietal. PURI, 1947, interprets the inverted parietal placentation strands in *Passiflora* as supporting their possible derivation from axile placentae. Long ago PAYER considered the central placentation of *Primula* as primitive, a view recently defended by MCLEAN-THOMPSON and also by HAGERUP. HAGERUP compares the attachment of ovules in *Polygonum* with that in *Juniperus.*

Ovule and Seed:— The ovule before fertilization includes the embryo sac, the nucellus and integuments. Usually the pollen tube enters the ovule through the micropyle, in a few families, including *Fagaceae* and *Casuarinaceae,* through the chalaza. After fertilization the endosperm enlarges first, then the embryo. The nucellus is usually absorbed and that often happens to the endosperm. The development of the integuments varies greatly, but usually the seed coats develop from only a part of the integuments. Two seed coats are common in dicotyledons, but most Sympetalae, also *Umbellales, Betulaceae, Juglandaceae* and others have only one. In cycads and in *Ginkgo* the outer layers of the seed coats are fleshy, resembling *Magnolia* and *Caulophyllum.* The inner coat may be the principal protective part, as in *Malvaceae* and *Violaceae;* or it may be the outer, as in *Papaveraceae* and *Cruciferae.*

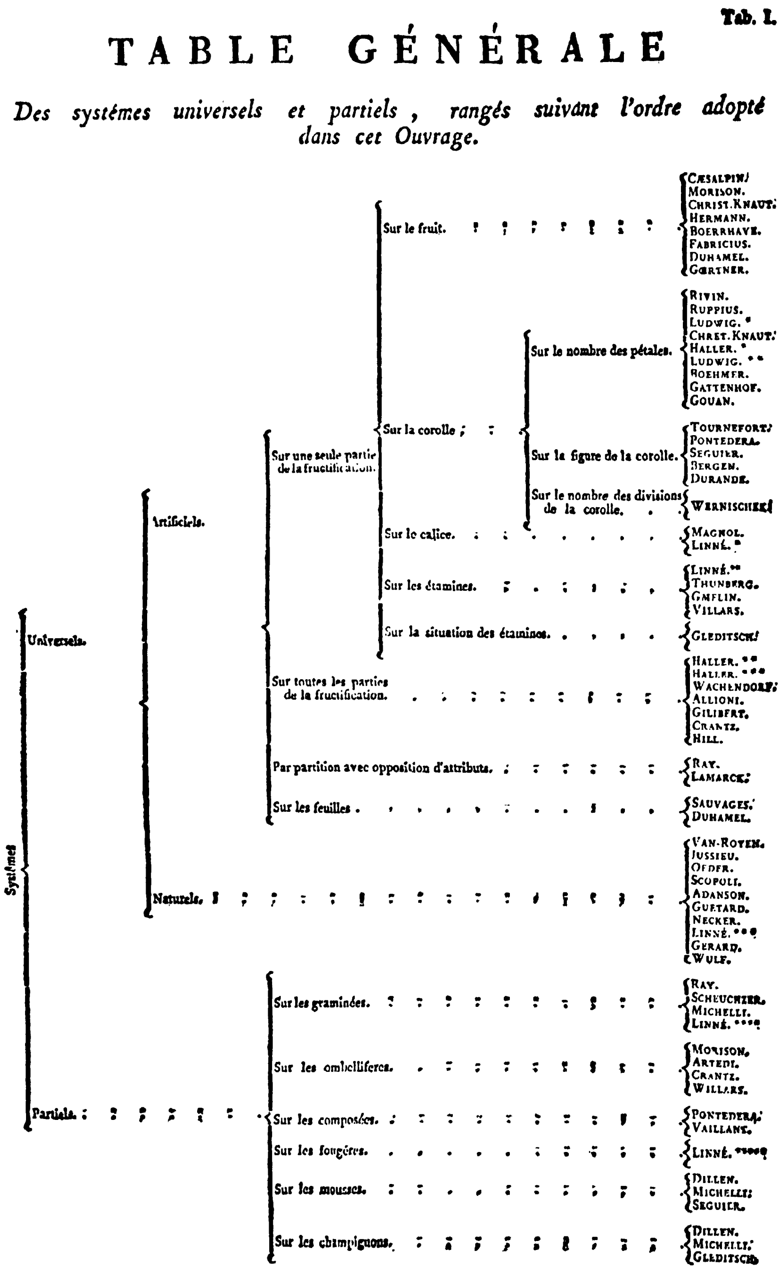
Many sections of seeds were illustrated by MARTIN, 1946, showing the embryo and the endosperm. A small embryo in abundant endosperm is probably primitive; that occurs in *Magnoliaceae* and related families, also in *Piperaceae, Papaveraceae, Aquifoliaceae, Caprifoliaceae* and others. Does the presence of perisperm in *Nymphaeaceae, Piperaceae, Caryophyllaceae, Chenopodiaceae* and other families have phylogenetic significance? MARTIN'S "peripheral group" includes *Centrospermae, Polygonaceae, Cactaceae* and *Frankeniaceae;* he considers them as a terminal group. In these a curved embryo usually surrounds perisperm, but the embryo is straight or nearly so in *Dianthus, Oxyria, Pisonia, Batis* and *Frankenia.* In *Frankenia* the embryo is on one side of the seed, of interest in connection with the many other resemblances between *Frankenia* and *Dianthus.* The absence or near absence of endosperm is characteristic of cycadeoids and of many dicotyledons, including *Lauraceae, Calycanthaceae, Cruciferae, Cucurbitaceae, Rosaceae, Leguminosae, Proteaceae, Myrtaceae, Fagaceae, Sapindaceae, Juglandaceae, Compositae* and many others. Isely, 1947, describes and illustrates seeds of important families, emphasizing internal gross morphology.

Important lines of evolution of seeds appear to have been: seed coats, from two to one or to none; embryo, from small to large, from straight to curved; endosperm, from presence to absence.



Part 3

HISTORICAL NOTES



Tab. I.

TABLE GÉNÉRALE

Des systémes universels et partiels, rangés suivant l'ordre adopté dans cet Ouvrage.

- Systémes
  - Universels.
    - Artificiels.
      - Sur une seule partie de la fructification.
        - Sur le fruit.
          - Cæsalpin.
          - Morison.
          - Christ. Knaut.
          - Hermann.
          - Boerrhave.
          - Fabricius.
          - Duhamel.
          - Gærtner.
        - Sur la corolle
          - Sur le nombre des pétales.
            - Rivin.
            - Ruppius.
            - Ludwig. *
            - Chret. Knaut.
            - Haller. *
            - Ludwig. **
            - Boehmer.
            - Gattenhof.
            - Gouan.
          - Sur la figure de la corolle.
            - Tournefort.
            - Pontedera.
            - Seguier.
            - Bergen.
            - Durande.
          - Sur le nombre des divisions de la corolle.
            - Wernischeck.
        - Sur le calice.
          - Magnol.
          - Linné. *
        - Sur les étamines.
          - Linné. **
          - Thunberg.
          - Gmelin.
          - Villars.
        - Sur la situation des étamines.
          - Gleditsch.
      - Sur toutes les parties de la fructification.
        - Haller. **
        - Haller. ***
        - Wachendorf.
        - Allioni.
        - Gilibert.
        - Crantz.
        - Hill.
      - Par partition avec opposition d'attributs.
        - Ray.
        - Lamarck.
      - Sur les feuilles.
        - Sauvages.
        - Duhamel.
    - Naturels.
      - Van-Royen.
      - Jussieu.
      - Oeder.
      - Scopoli.
      - Adanson.
      - Guettard.
      - Necker.
      - Linné. ***
      - Gerard.
      - Wulf.
  - Partiels.
    - Sur les graminées.
      - Ray.
      - Scheuchzer.
      - Michelli.
      - Linné. ****
    - Sur les ombelliferes.
      - Morison.
      - Artedi.
      - Crantz.
      - Willars.
    - Sur les composées.
      - Pontedera.
      - Vaillant.
    - Sur les fougéres.
      - Linné. *****
    - Sur les mousses.
      - Dillen.
      - Michelli.
      - Seguier.
    - Sur les champignons.
      - Dillen.
      - Michelli.
      - Gleditsch.

A SYNOPSIS OF THE EARLY SYSTEMS OF PLANT CLASSIFICATION, ACCORDING TO MOUTON-FONTENILLE (1795).

The history of plant classification is an interesting study, wrote RENDLE. In plants as in animals early classifiers noted first the obvious characters; only very gradually did less obvious but more significant ones come to be recognized. The following notes relate mostly to dicotyledons.

Seventeenth Century: — LOBELIUS (d. 1616) classified plants by leaves, thus separating to some extent dicotyledons from monocotyledons.

BAUHIN'S Pinax, about 1620, described 6,000 species under genera, but the genera were not described. Many of our families, such as *Cruciferae, Solanaceae, Cucurbitaceae* and others were kept together, but were not named or marked off in any way. "From BAUHIN'S time onward," writes SPRAGUE, "there has been a gradual increase in what may be termed the permanent part of the classification of angiosperms."

TOURNEFORT'S widely used work (1700) clearly described genera and also species, with many illustrations; he emphasized characters of the corolla.

Eighteenth Century: — JOHN RAY, following a suggestion of NEHEMIAH GREW, was the first to use the term *dicotyledones,* his groups of 1703 were:

- *Herbae*
  - *Flore destitutae*
  - *Floriferae*
    - *Dicotyledones*
    - *Monocotyledones*
- *Arbores*
  - *Flore a fructu remoto*
  - *Flore fructui contiguo*

MAGNOL (d. 1715) used the term "famille". "Plants have a certain affinity," he wrote, "which does not exist in any part considered separately, but only as a whole."

LINNAEUS (1707-1778) used the terms monocotyledones and dicotyledones only in classifying seeds. He named fifty-eight "natural orders," giving their genera, but not describing them.

In his artificial system plants with one stamen formed Class 1, those with two stamens, Class 2, and so on up to ten stamens; then eleven to nineteen stamens in Class 11, twenty or more stamens on the calyx, Class 12; in all, 24 classes. The number of carpels, a word not used until later, formed subdivisions. His method was but a thread of Ariadne, said LINNAEUS, to help him find a way in the labyrinth of facts.

BERNARD DE JUSSIEU and his nephew, ANTOINE LAURENT DE JUSSIEU, are justly considered as founders of a first approximation to a natural classification of plants. The plant world (1789) was divided into *Acotyledones, Monocotyledones,* and *Dicotyledones;* these into 15 classes, in all, 100 orders. *Dicotyledones* include four groups: *Apetalae* (beginning with *Aristolochiae*), *Monopetalae, Polypetalae* and *Diclines Irregulares.*

Nineteenth Century: — A. P. DE CANDOLLE in 1813, some years before beginning the Prodromus, proposed the system:

- *Vasculares*
    - *Exogenae* or *Dicotyledoneae*
        - *Diplochlamydeae* (beginning with *Ranunculaceae*)
        - *Monochlamydeae*
    - *Endogenae* or *Monocotyledoneae*
        - *Phanerogamae*
        - *Cryptogamae*
- *Cellulares*

"I place *Ranunculaceae* first," DE CANDOLLE wrote, "because they have the greatest number of distinct and separate parts. Let no one imagine I attach the least importance to the arrangement."

ROBERT BROWN in 1827 pointed out gymnospermy and other characters of cycads and conifers; he was opposed to the Linnaean system. He introduced many new natural orders, mostly with the termination -eae.

HORANINOV, 1834, used -aceae as termination for orders; LINDLEY, 1836, proposed -aceae termination for orders, -eae for tribes, -ales for alliances; he used -gens as termination for his seven main groups, such as *Gymnogens* and *Exogens.*

ENDLICHER, 1840, half a century after JUSSIEU, dedicating his work to him and using the same title, "Genera plantarum secundum ordines naturales disposita," completed the first comprehensive description of genera since JUSSIEU; he also began with the lower plants. His last group, *"Acramphibrya,"* included *Gymnospermae, Apetalae* (beginning with catkin-bearing plants), *Gamopetalae* and *Dialypetalae,* ending with *Leguminosae.*

BRONGNIART, 1843, divided dicotyledons into *Angiospermes* and *Gymnospermes,* thus:

Phanerogames
  Monocotyledones
  Dicotyledones (*Angiospermes* and *Gymnospermes*)

The far-reaching studies of HOFMEISTER, according to BONNIER "perhaps the greatest genius of botanical science," made clear the importance of the phenomenon of alternation of generations. Early system-makers seized upon more or less arbitrary characters, often very effective to find the names of plants. HOFMEISTER emphasized resemblances, implying, though not stating, the doctrine of evolution.

A decade later DARWIN'S "Origin of Species" (1859) became a subject of general controversy. "Although fully convinced of the truth of these views," he wrote, "I by no means expect to convince experienced naturalists." In America his ideas were strenuously opposed by AGASSIZ, but defended by ASA GRAY.

PAYER in his Organogénie de la Fleur (1857) illustrated floral development.

ALEXANDER BRAUN, botanist and nature-philosopher, combined suggestions from ROBERT BROWN, ENDLICHER and others, and in 1864 made the great improvement of subordinating *Monocotyledones* and *Dicotyledones* under *Angiospermae,* thus at last giving dicotyledons their present content. His groups were:

Anthophyta
  Gymnospermae (*Frondosae and Acerosae*)
  Angiospermae (*Monocotyledones and Dicotyledones*)

GEORGE BENTHAM collaborated on DE CANDOLLE'S Prodromus, later BENTHAM and HOOKER prepared the Genera Plantarum (1862-1883), "the greater portion being the product of BENTHAM'S indefatigable industry," according to HOOKER. The main divisions are *Dicotyledones, Gymnospermae, Monocotyledones.* While in the text gymnosperms are included in dicotyledons, in the list of contents they are put up as a separate group. Dicotyledons are divided into *Polypetalae, Gamopetalae* and *Monochlamydeae. Polypetalae* include three series with "cohorts" as follows:

I. *Ranales, Parietales* (inc. *Cistus* and *Papaver*), *Polygalineae, Caryophyllinae,* inc. *Frankenia* and *Dianthus* (but not *Chenopodium*), *Guttiferales, Malvales.*

II. *Geraniales, Olacales* (inc. *Ilex*), *Celastrales, Sapindales.*

III. *Rosales, Myrtales, Passiflorales* (inc. *Cucurbita*), *Ficoidales* (inc. *Cactus* and *Mesembryanthemum*) and *Umbellales,* in all 165 families of dicotyledones (then called orders).

EICHLER'S studies of flower structure (Blütendiagramme, 1878) made more definite groups of families. He followed ENDLICHER in many ways, such as in beginning dicotyledones with catkin-bearing plants, but he moved *Sympetalae* to the end, thus:

Dicotyleae
  Choripetalae (beginning with *Amentaceae,* ending with *Leguminosae*)
  Sympetalae (ending with *Compositae*)

Die natürlichen Pflanzenfamilien, the great cooperative work edited by ENGLER and PRANTL, appeared in the last decade of the nineteenth century. An abridged outline of dicotyledons follows:

  Archichlamydeae (beginning with *Casuarinaceae,* ending with *Cornaceae*)
Catkin-bearing and other woody apetalous plants (f. ex. *Ulmus*)
Centrospermae, mostly apetalous herbs (inc. *Dianthus*)
Ranales, fl. parts spiral or spirocyclic, hypogynous, separate, embryo small, in endosperm (*Magnolia*)
Rhoeadales, sts. in part many, embryo often small, in endosperm (*Papaver*)
Rosales, sts. usually many, petals and sts. perigynous (*Rosa*)
Geraniales, ste. whorls mostly two, often obdiplostemous (*Geranium*)
Malvales, sts. many, more or less united (*Malva*)
Parietales, fl. parts often spirocyclic, plac. parietal (*Cistus, Frankenia*) or axile (*Thea*)
Umbelliflorae, calyx lobes small, sts. 1 whorl, ovary inferior, endosperm abundant (*Cornus*)
  Sympetalae (beginning with *Clethraceae,* ending with *Compositae*)
Ovary superior (*Jasminum*)
Ovary inferior (*Rubia*)

Systems since 1900: — BESSEY, 1897 and 1915, considered dicotyledons as forming two main lines: a *Ranunculus* series, with receptacle an axis, and a *Rosa* series, with receptacle more or less cupshaped; apetalous flowers are considered as reduced forms; CLEMENTS, SCHAFFNER and POOLE developed this system.

ROBERTSON, 1904, gave many reasons for believing that insect-pollinated flowers are primitive in angiosperms.

ARBER and PARKER, 1907, explained angiospermy as an adaptation to protect the ovules from insect visitors. Among gymnosperms wind-pollination is primitive and nearly universal, but evidence has accumulated that in angiosperms wind-pollination is a secondary character.

HALLIER, 1905 and 1913, urged that all characters be considered in classification; he gave many reasons for considering *Ranales* as primitive angiosperms; he was strongly opposed to the ENGLER system.

WERNHAM, 1911, concluded that *Sympetalae* have developed from polypetalous ancestors along at least seven lines, for example *Passifloraceae-Cucurbitaceae.*

WARMING, 1912, WARMING-MÖBIUS, 1929, and WETTSTEIN (1901, 1911, 1924, 1935) also began dicotyledons with *Casuarina* and catkin-bearing plants. They placed *Cactaceae* near *Aizoaceae, Rhoeadales* near *Parietales.* WETTSTEIN'S work, including the entire plant world, often presents opposite points of view.

RENDLE, 1925, presenting in the main the ENGLER system of dicotyledons, makes departures toward the BENTHAM & HOOKER system. "The arrangement does not claim to be strictly phylogenetic," says RENDLE, "various attempts have been made to construct a phylogenetic system of Angiosperms, but the results are not convincing, bear no suggestion of permanence, and fairly bristle with difficulties for the student." Some differences from ENGLER: *Piperales* after *Polygonales* (like WARMING); *Rhoeadales* followed by *Sarraceniales* and *Parietales; Rosales* followed by *Myrtiflorae.*

HUTCHINSON, 1926, separates *Woody Dicotyledons* and *Herbaceous Dicotyledons,* but maintains *Archichlamydeae* and *Metachlamydeae.* "A key mostly emphasizes differences," says HUTCHINSON, "a truly natural and phylogenetic classification should emphasize resemblances, by which alone true affinities may be ascertained." Some features in common with RENDLE, differing from ENGLER, are: *Casuarinaceae* after *Fagaceae; Magnoliaceae* before *Nymphaeaceae; Balsaminaceae* near *Tropaeolaceae, Cucurbitaceae* near *Passifloraceae.* Other differences from ENGLER: *Elatinaceae* is followed by *Caryophyllaceae, Proteaceae* near *Thymelaeaceae, Calycanthaceae* near *Rosaceae, Stachyuraceae* precedes *Hamamelidaceae.* Among points difficult to accept are: *Hydrangeaceae* far from *Saxifragaceae, Myrsinaceae* far from *Primulaceae,* the statement that such apparently natural groups as *Umbelliferae, Compositae* and *Urticales* are probably polyphyletic.

WARMING-MÖBIUS, 1929, some differences from ENGLER: *Juglandaceae* and *Myricaceae* in same order; *Polygonaceae* and *Piperaceae* in same order; *Monimiaceae* follows *Calycanthaceae; Resedaceae* in *Cistiflorae. Burseraceae* and *Anacardiaceae* in same order; *Thymelaeaceae* etc. in same order with *Proteaceae; Leguminosae* is an order, followed by *Myrtiflorae* and *Umbelliflorae.* The order *Nuculiferae* includes *Boraginaceae, Verbenaceae, Labiatae* and others; the last order *Synandrae* includes only *Compositae.*

WETTSTEIN, 1935, some differences from ENGLER: *Julianiaceae* and *Juglandaceae* in the same order; *Cactaceae* with *Aizoaceae* and *Caryophyllaceae,* these followed by *Euphorbiaceae; Hamamelidales* is an order before *Ranales; Ranales* begins with *Mag-*

noliaceae; Myristicaceae is followed by *Canellaceae; Rhoeadales* followed by *Parietales; Rosales* followed by *Myrtales. Sympetalae* begin with *Plumbaginaceae; Oleaceae* is a separate order.

Burtt-Davy, 1937, cooperating with Chalk, wood anatomist, classifies dicotyledons into three subclasses, these into divisions, subdivisions, sections, cohorts, orders and families; in all 28 cohorts, 62 orders.

Subclass I. *Amentiferae* (f. ex. *Garrya, Juglans, Betula, Salix*).
Subclass II. *Polystemonae*
  Division *Apocarpicae* (*Magnolia, Cactus, Ranunculus, Rosa*)
  Division *Syncarpicae* (*Diospyros, Thea, Myrtus, Malva, Cistus*)
Subclass III. *Oligostemonae*
  Divsion *Pentacyclicae* (*Acer, Geranium, Dianthus*)
  Division *Tetracyclicae* (*Celastrus, Cornus, Convolvulus, Aster, Mentha*)

Sprague 1940, though not proposing a new system, has made numerous suggestions regarding dicotyledons. The so-called natural classification has been developed synthetically, by a process of trial and error, and is not based on an arbitrary selection of characters. The group *Malvaceae* was discovered, not made, by taxonomists. *Cucurbitaceae* was recognized as a family long before it was found that they possess bicollateral vascular bundles. *Polygalaceae* were known long before it was recognized they have highly peculiar pollen grains.

Skottsberg, 1940, begins with *Casuarinaceae*, but this is followed by *Magnoliaceae*. We compare his arrangement of orders with those in this book:

Orders Compared: —

Skottsberg, 1940	Gundersen, 1950
Verticillatae	*Magnoliales*
Polycarpicae	(*Ranales*)
Aristolochiales	*Piperales*
(*Nepenthales*)	
Sarraceniales	*Cactales*
Piperales	*Cistales*
Polygonales	*Salicales*
Centrospermae	*Papaverales*
Cactales	*Sarraceniales*
Rhoeadales	*Aristolochiales*
Parietales	(*Tamaricales*)
(*Cucurbitales*)	
Guttiferales	*Theales*

Rosales
(*Podostemonales*)
(*Hydrostachyales*)
Myrtales
Hamamelidales
Salicales
(*Garryales*)
(*Myricales*)
Balanopsidales
Leitneriales
Juglandales
(*Julianiales*)
Fagales
(*Batidales*)
Urticales
Proteales
Santalales
(*Balanophorales*)
Columniferae
Tricoccae
(*Callitrichales*)
Gruinales
(*Pandales*)
Terebinthales
(*Polygalales*)
Sapindales
Celastrales
(*Rhamnales*)
Umbelliflorae

(*Plumbaginales*)
Primulales
Bicornes
Diospyrales
Tubiflorae
Contortae
(*Ligustrales*)
Plantaginales
Rubiales
Campanulatae
Synandrae

(53 orders)

Ebenales
Ericales

Rosales
Hamamelidales
(*Thymelaeales*)
Myrtales

Proteales?
Urticales
Balanopsidales
Fagales
Leitneriales
Casuarinales?

Malvales
Euphorbiales

Rutales
Juglandales
Sapindales
Celastrales
Santalales
Geraniales

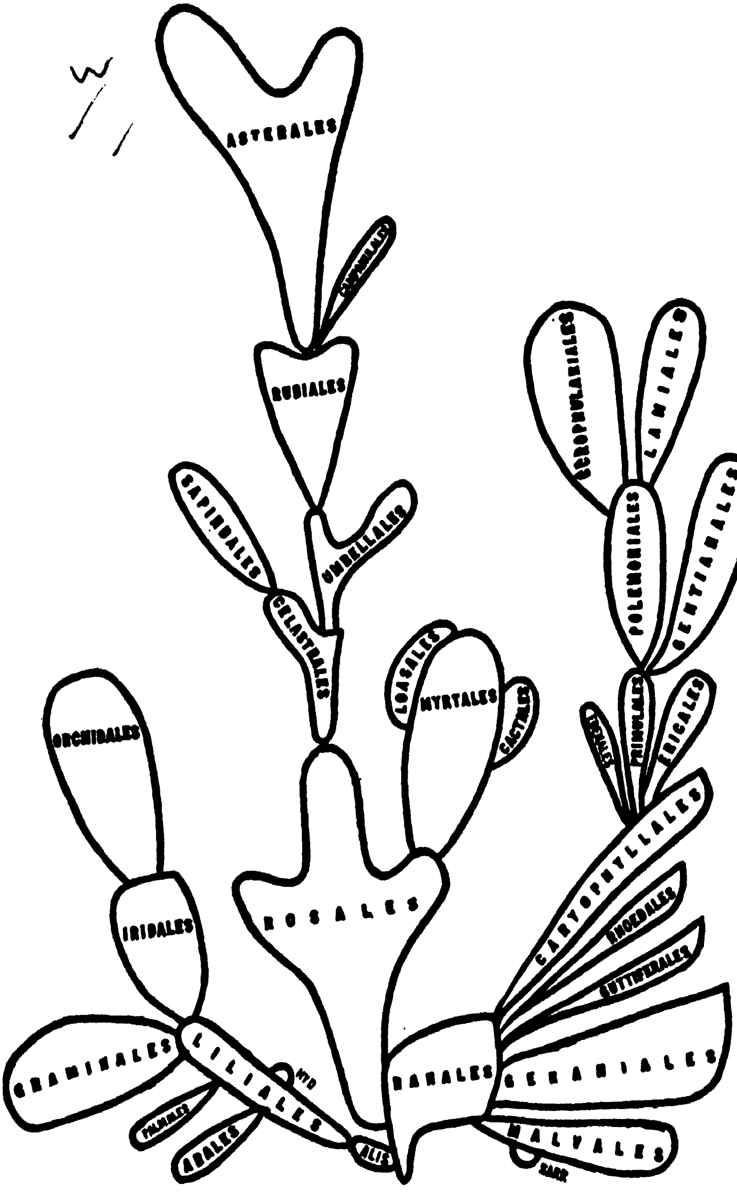
Caryophyllales
Polygonales
Primulales
Plantaginales

Loganiales
Polemoniales
(*Boraginales*)
Campanales

Umbellales
Rubiales
Asterales

(42 orders)

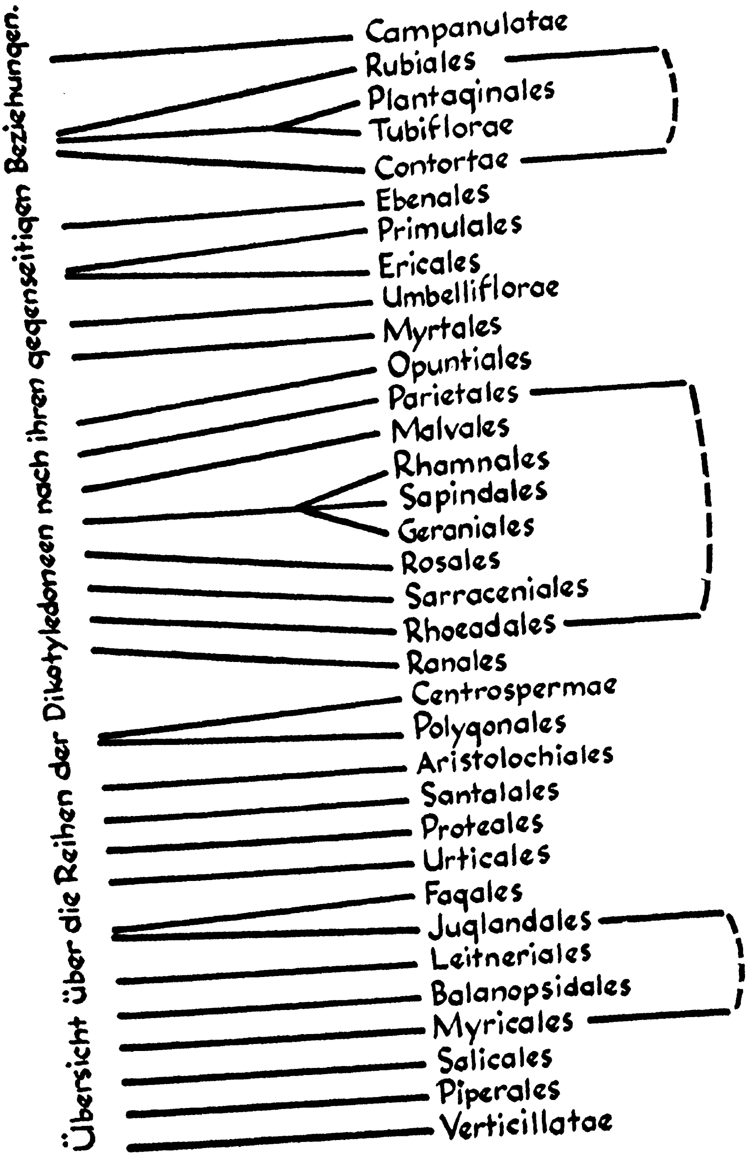
Orders which do not occur in the opposite column have been placed between parentheses!



Bessey's Diagram (1914)

Part 4

SYSTEMATIC ARRANGEMENT



ENGLER'S DIAGRAM OF 1897. — The converging lines suggest that the ten orders *Ranales — Opuntiales* are related. More closely related, according to ENGLER'S view, are the *Rhoeadales — Parietales* and the *Geraniales — Sapindales — Rhamnales.*

Beginning the System: — A. L. DE JUSSIEU began dicotyledons with *Aristolochiae*. EICHLER, 1883, began with *Cupuliferae*, ENGLER with *Casuarinaceae*, as did WARMING, WETTSTEIN and many others. RENDLE, 1925, began with *Salicaceae*. DE CANDOLLE began with *Ranunculaceae*, more nearly the right way according to present views, but he considered that group the most advanced. *Ranunculaceae* is the beginning also of BENTHAM and HOOKER and of ASA GRAY. "There is no highest or lowest order among phanerogams," wrote ASA GRAY. BESSEY, and also HUTCHINSON, began with *Magnoliaceae;* HALLIER with *Annonaceae*, later with *Berberidaceae*.

This book begins with *Winteraceae*, as most nearly representing primitive dicotyledons, according to I. W. BAILEY. The other vesselless ranalean family, *Trochodendraceae*, and the vessel-bearing *Degeneriaceae*, *Himantandraceae* and other families also retain primitive ranalean features. Until the missing fossils are discovered, says BAILEY, probable ancestral forms can only be synthesized from primitive features of different families.

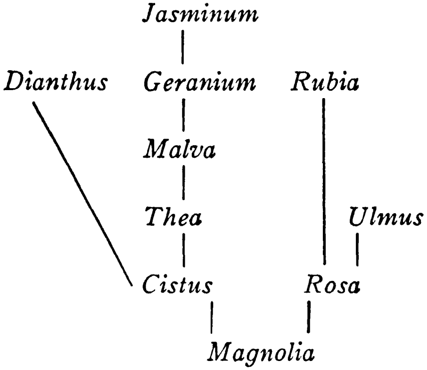
Sequence of Groups: — Many and varied facts imply that *Ranales* in a broad sense include the most primitive of living dicotyledons. But what should be the next group? Perhaps DE CANDOLLE and BENTHAM and HOOKER had the right idea, that the second group should be *"Parietales"* in a broad sense. In this connection we note the sequence of a few genera in various systems, taking these genera to represent large groups. DE CANDOLLE, BENTHAM and HOOKER, and EICHLER, before the Engler system, used the sequence *Magnolia, Papaver, Cistus, Geranium.* These genera have the same sequence in the systems of WARNING, WETTSTEIN, and RENDLE, which are subsequent to the ENGLER system.

But ENGLER'S sequence is *Magnolia, Papaver, Geranium, Cistus.*

It may be that the separation of the *Papaver* and *Cistus* groups of families in the ENGLER system was not justified, that they are approximately right in the other systems. ENGLER already in 1897 recognized a relationship between the *Cistus* and *Papaver* groups, as shown in his diagram of dicotyledons of that year. Numerous characters are common to certain families of *Rhoeadales* and *Parietales;* many characters generally considered primitive occur in these groups.

That *Archichlamydeae* and *Sympetalae* are artificial groups is now widely recognized, and Axis-flowers versus Cup-flowers, Woody vs. Herbaceous Dicotyledons, *Polystemonae* vs. *Oligostemonae,* are hardly very different in this respect. Surely many families and some orders are natural groups and seem to connect with others. Facts appearing to have a bearing on the position of families are many, but not always readily combined with other facts. A linear arrangement of families is artificial, though necessary for publications and for collections. Doubtless a natural arrangement should be branching like a tree or more probably like a shrub; it should include fossil plants, as yet a distant ideal. In the animal world a number of invertebrates were nearly the same in far-away Devonian times as they are at present. Among Dicotyledons *Magnolia, Sassafras, Populus, Liquidambar, Platanus* and others may not have been very different in the days of the dinosaurs from what they are today, but most herbaceous plants seem to have originated since that time.

Many diagrams to indicate supposed relationships of plants have been published, that of ENGLER has been mentioned. More recent ones of dicotyledons include that of WETTSTEIN of 1935; of TAKHTAJAN, 1942; of HUTCHINSON, 1946. If we disregard WETTSTEIN's beginning with wind-pollinated plants, likewise HUTCHINSON's groups woody and herbaceous plants, then we see that these outlines agree in presenting widely accepted ideas. In the diagram which follows well-known genera are taken to represent large, tentative groups. The termination *-florae* has been given to six of these groups in the list of contents, intended to suggest that they may have a better claim than others to be considered as natural groups; for the *Ulmus* and the *Malva* groups the opposite is the case. Much oversimplified, six groups seem to form a main line, four groups are sidelines; more likely all are sidelines. The necessary linear arrangement in the systematic part compromises toward usage in placing the *Rosa* group near the beginning, the *Rubia* group at the end.



Nomenclature: — *Dicotyledones* was the form used by Ray, by Jussieu and by Bentham and Hooker; de Candolle used both *Exogenae* and *Dicotyledoneae;* the last, taken up in the *Pflanzenfamilien,* has been widely used. Eichler's form was *Dicotyleae.*

The order names *Myrtales* and *Umbellales* as of Bentham and Hooker are here used rather than *Myrtiflorae* and *Umbelliflorae,* partly to reserve the *-florae* termination for groups larger than orders. Many of Hutchinson's names are used: *Casuarinales* rather than *Verticillatae, Cactales* (as of Warming) for *Opuntiales, Papaverales* (as in Gray's Manual and in Britton & Brown's Flora) for *Rhoeadales,* and others.

The family names *Boraginaceae, Haloragaceae, Melastomaceae, Onagraceae* and *Podostemaceae,* as of Bentham and Hooker, are used (Sprague 1922, 1928), also *Amaranthaceae* and *Thelygonaceae,* as of Diels; these differ from the *Pflanzenfamilien* forms.

Scope of Orders and of Families: — Groups of families, such as the alliances of Lindley, cohorts of Bentham and Hooker and of Asa Gray, Reihen of Eichler and of Engler, are now generally called orders; their number in dicotyledons has been as follows:

Eichler, 1883	30	Wettstein, 1935	39
Engler, 1903	35	Diels, 1936	44
Warming, 1912	40	Skottsberg, 1940	53
Hutchinson, 1926	76		

Hutchinson includes a number of orders containing a single family; such are *Cruciales, Malvales, Meliales, Gentianales,* and others. On the other hand, Moss said in 1913 that some of Engler's orders, such as *Geraniales,* are so comprehensive as to be quite unmanageable. Engler's *Centrospermae, Rhoeadales, Malvales, Ericales, Tubiflorae* and *Contortae* are natural orders, says Sprague, but others, such as *Geraniales* and *Sapindales,* are not natural.

In this book 42 orders have been used; as compared with Diels' 44 orders, 8 have been added and 10 have been subordinated. The 8 added are: *Magnoliales, Tamaricales, Theales, Euphorbiales, Rutales, Thymelaeales, Boraginales* and *Asterales.* The 10 subordinated are: *Garryales, Podostemonales, Hydrostachyales, Batidales, Myricales, Julianiales, Pandales, Plumbaginales, Diapensiales* and *Cucurbitales.*

The number of families in dicotyledons has been as follows:

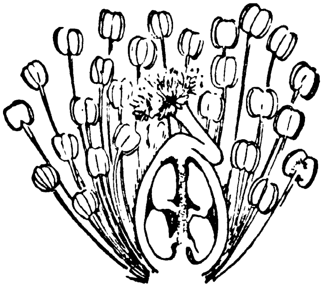
Prodromus, completed 1873	214	Hutchinson, 1926	264
Bentham and Hooker, 1880	165	Möbius, 1929	200
Engler, 1900	230	Wettstein, 1935	261
De Dalla Torre and Harms, 1907	237	Diels, 1936	259

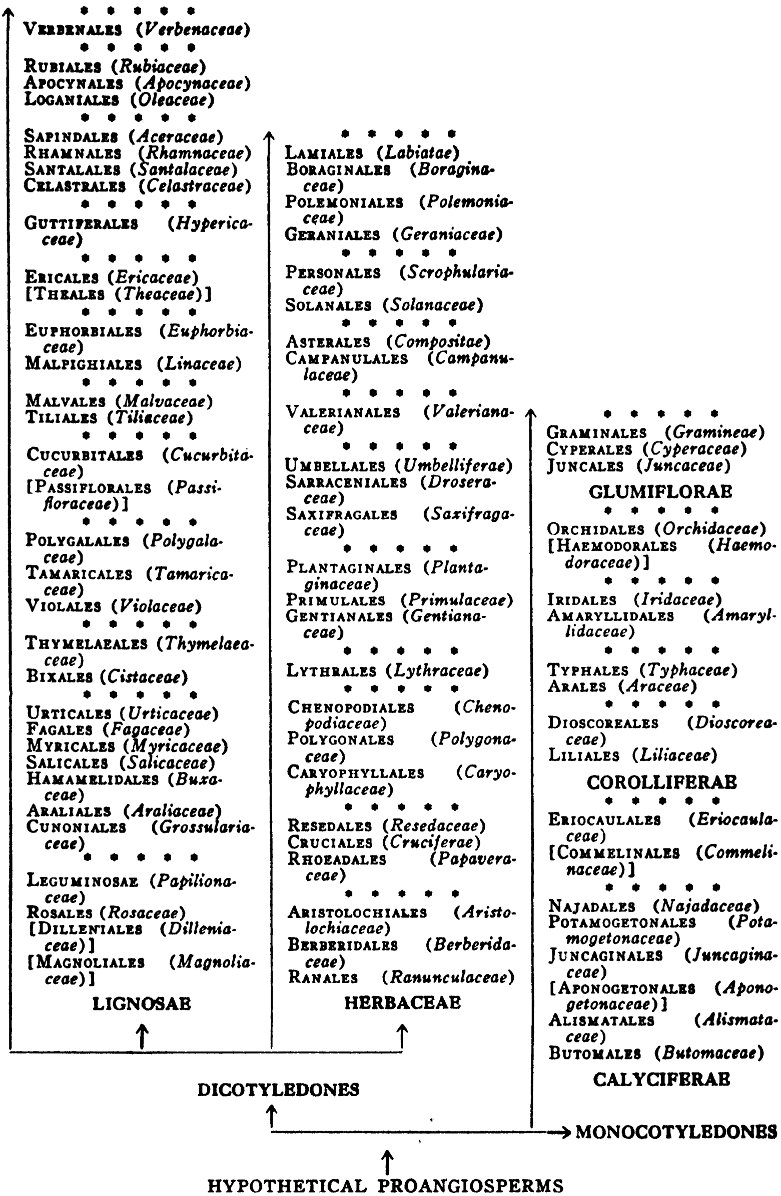
Jussieu had recognized just 100 orders for the plant world. Bentham and Hooker recognized just 200 for phanerogams, later adding two (*Vochysiaceae* and *Cyrillaceae*) ; they followed almost exactly the sequence of the *Prodromus,* but reduced the number of families (then called orders) from 214 to 165. Engler in 1900 recognized 230 families of dicotyledons; of these, five, namely *Lacistemaceae, Humiriaceae, Gonystylaceae, Triplochitonaceae* and *Koeberliniaceae,* have been subordinated in later editions of the *Syllabus.* Hutchinson in 1926 subordinated about a dozen of Engler's families (*Hippocastanaceae, Theophrastaceae* and others), while Diels in 1936 subordinated 26 of Hutchinson's families.

Chenopodiaceae and *Amaranthaceae* are separated only for convenience, says Schinz. *Rubiaceae* and *Caprifoliaceae* should be separated, but along new lines, says Wernham. Sprague gives reasons for placing *Adoxaceae* under *Saxifragaceae;* he says, like Hallier, that *Diclidantheraceae* is not a family, but belongs under *Polygalaceae.*

"There is great inequality in importance of criteria employed to separate families," wrote W. W. Smith, 1934. "Families in *Gamopetalae* are nearer together than those in *Polypetalae.* Quite distinct new families are now likely to be found very rarely. Is it the correct procedure to divide families? Bessey made 14 families of *Compositae.* Is it expedient to have many minor alterations?"

Of the various forms of the ENGLER system, that of DE DALLA TORRE and HARMS has the advantage of including a systematic enumeration of genera in a single volume; the number of families of dicotyledons is 237, in this book 240. Compared with DIELS' Syllabus, 1936, with 259 families, 9 have been added, 28 subordinated. The 9 added are *Chrysobalanaceae, Cichoriaceae, Degeneriaceae, Eupteleaceae, Hydrangeaceae, Mimosaceae, Pomaceae, Schisandraceae* and *Winteraceae*.





* * * * *

Verbenales (*Verbenaceae*)

* * * * *

Rubiales (*Rubiaceae*)
Apocynales (*Apocynaceae*)
Loganiales (*Oleaceae*)

* * * * *

Sapindales (*Aceraceae*)
Rhamnales (*Rhamnaceae*)
Santalales (*Santalaceae*)
Celastrales (*Celastraceae*)

* * * * *

Guttiferales (*Hypericaceae*)

* * * * *

Ericales (*Ericaceae*)
[Theales (*Theaceae*)]

* * * * *

Euphorbiales (*Euphorbiaceae*)
Malpighiales (*Linaceae*)

* * * * *

Malvales (*Malvaceae*)
Tiliales (*Tiliaceae*)

* * * * *

Cucurbitales (*Cucurbitaceae*)
[Passiflorales (*Passifloraceae*)]

* * * * *

Polygalales (*Polygalaceae*)
Tamaricales (*Tamaricaceae*)
Violales (*Violaceae*)

* * * * *

Thymelaeales (*Thymelaeaceae*)
Bixales (*Cistaceae*)

* * * * *

Urticales (*Urticaceae*)
Fagales (*Fagaceae*)
Myricales (*Myricaceae*)
Salicales (*Salicaceae*)
Hamamelidales (*Buxaceae*)
Araliales (*Araliaceae*)
Cunoniales (*Grossulariaceae*)

* * * * *

Leguminosae (*Papilionaceae*)
Rosales (*Rosaceae*)
[Dilleniales (*Dilleniaceae*)]
[Magnoliales (*Magnoliaceae*)]

LIGNOSAE

* * * * *

Lamiales (*Labiatae*)
Boraginales (*Boraginaceae*)
Polemoniales (*Polemoniaceae*)
Geraniales (*Geraniaceae*)

* * * * *

Personales (*Scrophulariaceae*)
Solanales (*Solanaceae*)

* * * * *

Asterales (*Compositae*)
Campanulales (*Campanulaceae*)

* * * * *

Valerianales (*Valerianaceae*)

* * * * *

Umbellales (*Umbelliferae*)
Sarraceniales (*Droseraceae*)
Saxifragales (*Saxifragaceae*)

* * * * *

Plantaginales (*Plantaginaceae*)
Primulales (*Primulaceae*)
Gentianales (*Gentianaceae*)

* * * * *

Lythrales (*Lythraceae*)

* * * * *

Chenopodiales (*Chenopodiaceae*)
Polygonales (*Polygonaceae*)
Caryophyllales (*Caryophyllaceae*)

* * * * *

Resedales (*Resedaceae*)
Cruciales (*Cruciferae*)
Rhoeadales (*Papaveraceae*)

* * * * *

Aristolochiales (*Aristolochiaceae*)
Berberidales (*Berberidaceae*)
Ranales (*Ranunculaceae*)

HERBACEAE

* * * * *

Graminales (*Gramineae*)
Cyperales (*Cyperaceae*)
Juncales (*Juncaceae*)

GLUMIFLORAE

* * * * *

Orchidales (*Orchidaceae*)
[Haemodorales (*Haemodoraceae*)]

* * * * *

Iridales (*Iridaceae*)
Amaryllidales (*Amaryllidaceae*)

* * * * *

Typhales (*Typhaceae*)
Arales (*Araceae*)

* * * * *

Dioscoreales (*Dioscoreaceae*)
Liliales (*Liliaceae*)

COROLLIFERAE

* * * * *

Eriocaulales (*Eriocaulaceae*)
[Commelinales (*Commelinaceae*)]

* * * * *

Najadales (*Najadaceae*)
Potamogetonales (*Potamogetonaceae*)
Juncaginales (*Juncaginaceae*)
[Aponogetonales (*Aponogetonaceae*)]
Alismatales (*Alismataceae*)
Butomales (*Butomaceae*)

CALYCIFERAE

DICOTYLEDONES

→ **MONOCOTYLEDONES**

HYPOTHETICAL PROANGIOSPERMS

"Bird's-Eye View" of the arrangement of the principal groups (Orders) of Flowering Plants and chief family of each represented in the British flora. (Important non-British linking groups are shown in square brackets, and a row of * indicates a climax group.)—To be read from below upwards.

Hutchinson's Classification (1948)

MAGNOLIALES

Nearly all woody plants, mostly with oil-cells, fls. spiral or spirocyclic, all floral parts nearly always separate. Sts. usually many. Seed coats 2, in *Monimiaceae* sometimes 1; embryo small, endosperm abundant; in *Calycanthaceae* and *Lauraceae* no endosperm.

Basic chromosomes number, mostly from DARLINGTON *and* JANAKI *1945*:—

Annonaceae — Annona 7; *Asimina, Artabotrys* 9.
Calycanthaceae — Calycanthus, Chimonanthus 11.
Cercidiphyllaceae — Cercidiphyllum 19.
Eupteleaceae — Euptelea 14.
Lauraceae — Laurus 7 ?, *Cinnamomum, Lindera, Persea, Sassafras* 12.
Magnoliaceae — Michelia 14; *Liriodendron, Magnolia* 19.
Nymphaeaceae — Nelumbium 8, *Nuphar* 10, 12, 17, *Nymphaea* 14.
Schisandraceae — Illicium, Kadsura, Schisandra 14.
Trochodendraceae — Tetracentron, Trochodendron 19.
Winteraceae — Drimys 19.

1. WINTERACEAE

Trees and shrubs; s. Mexico to s. S. Am., e. Australia, Philippines to N. Zealand; gen. 6: *Drimys, Bubbia, Exospermum, Belliolum, Pseudowintera, Zygogynum.*

Vessels absent. Lvs. pellucid dotted, aromatic, exstipulate, stomata occluded. Floral axis short. Sepals 2-6, free or united, in *Drimys* calyptrate. Petals separate. Sts. not differentiated into filament, anther and connective; pollen distinctive, in tetrads. Carpels free (except *Zygogynum*) with conspicuous double stigmatic crests, spiral or whorled, more or less open. Ovules attached to the ventral surface, not to margins, of the conduplicate carpels. Seed with minute embryo, abundant endosperm. — In *Zygogynum* carpels fused, ovules apparently mostly on dorsal side. Family not closely related to *Magnoliaceae* proper.

BH, TH, DIELS sub *Magnoliaceae.* — HUTCHINSON, fam., 1921, incl. *Illicium* — SMITH, A. C., 1943, taxonomy. — BAILEY and NAST, 1944, 1945, morphology.

2. TROCHODENDRACEAE

Trees; Assam, China, Japan; gen. 2; *Trochodendron* and *Tetracentron.*

Vessels absent, growth rings conspicuous. Wood of the two genera similar, but different from Winteraceae in rays and parenchyma. Lvs. of *Trochodendron* with long petioles, polymorphic, pinnately veined, exstipulate; of *Tetracentron* palmately veined, stipulate. Stomata peculiar and similar. *Trochodendron* fls. no perianth, sts. numerous. *Tetracentron* 4 sepals, opp. 4 sts. Sts. of the two genera fundamentally similar, pollen in both tricolpate. Carpels laterally concrescent, with free styles. Fruits essentially similar, superficially different. Seeds of the two genera strikingly similar, seed coats 2, embryo very small in abundant endosperm. Developmental, anatomical, morphological similarities leave no doubt of close affinity between genera; not near *Euptelea* or *Magnoliaceae* proper.

BH sub *Magnoliaceae,* TH 90. — BAILEY and NAST, 1945. — NAST and BAILEY, 1945. — CROIZAT, 1947: *Trochodendron* and *Tetracentron* may be near *Platanus, Liquidambar* and *Cornaceae.*

3. DEGENERIACEAE

Trees; Fiji Ids.; sp. 1.

Vessels present, perforation plate scalariform. Lvs. *Magnolia*-like, but exstipulate, petiole node pentalacunar. Fl. axis short. Sepals much smaller than petals. Staminodes present; sts. not differentiated into filament, connective and anther. Carpel single, indehiscent, lamina of carpels conduplicate. Ovules many, in two rows, not marginal; one row with sessile ovules, the other with funicles.

BAILEY and SMITH, genus and fam., 1942.

4. MAGNOLIACEAE

Trees and shrubs; s. e. N. America to Mass.; s. e. Asia to Japan; gen. 9.

Vessels present, perforation plate usually scalariform. Lvs. alt., entire, leaf-buds covered by membranous stipules. Fl. axis usually elongated. Fls. often large, spiral or spirocyclic, mostly

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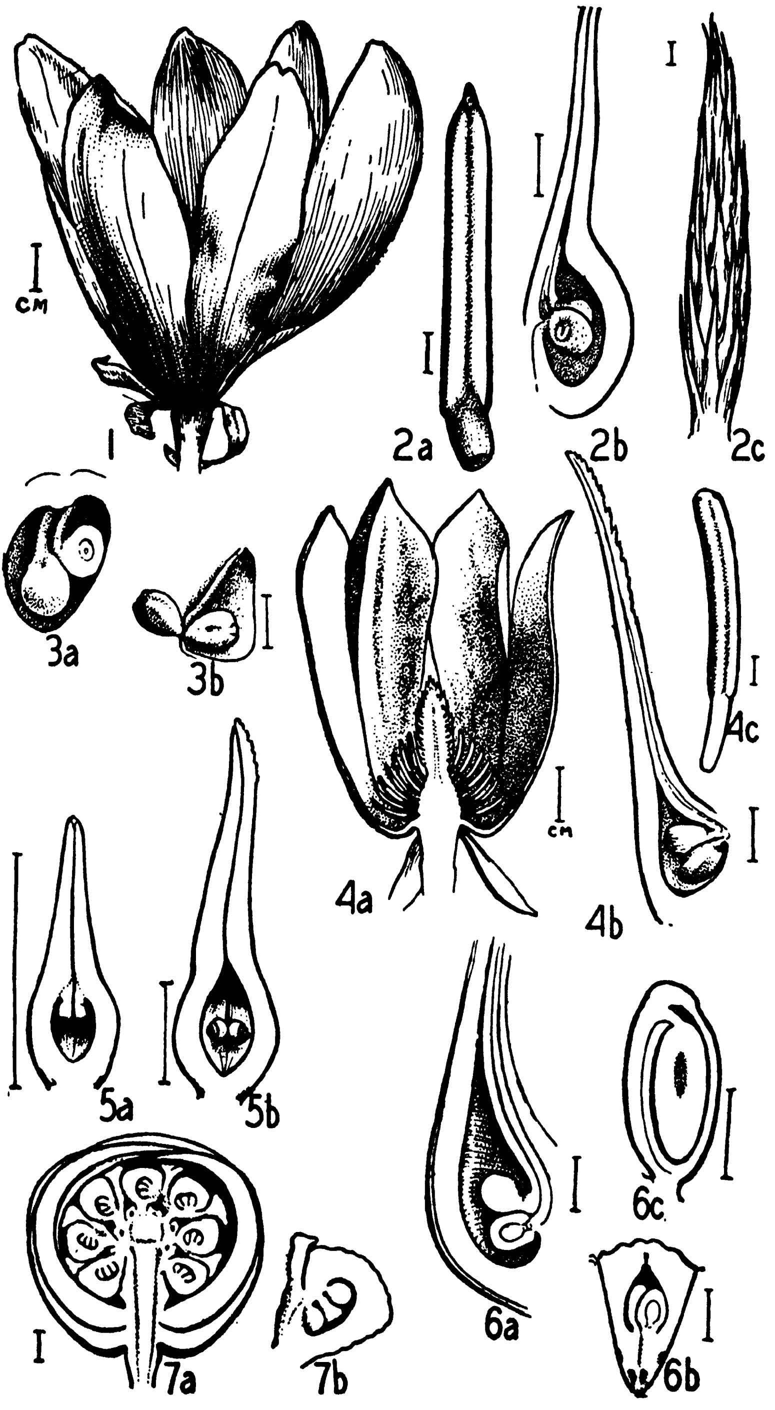
Magnoliaceae. — 1, *Magnolia liliflora,* three small sepals reflexed, two whorls of large petals, three in each. — 2, *M. denudata;* a: st., anther long, filament short (*cf. Paeonia*), connective projecting; b: carpel, two anatropous ovules; c: carp. column. — 3, *M. Soulangeana,* ovules. — 4, *M. acuminata;* a: fl., sepals reflexed, usually nine petals, many sts. and carpels; b: carpel, two ovules; c: st. — 5, *M. stellata;* a: carpel one mm.; b: carpel four mm. — 6, *M. tripetala;* a: carpel, lower part; b: cross sec.; c: ovule. — 7, *Kadsura japonica;* a: carp. fl. bud; b: single carpel, style nearly gynobasic (*cf. Drimys*).


cm
1
2a
2b
2c
3a
3b
4a
cm
4b
4c
5a
5b
6a
6b
6c
7a
7b

perfect, nectar glands none. Sts. usually many, staminodes none. Carpels many, rarely united; seeds several, anatropous, embryo small, endosperm abundant.

BH 4, TH 95. — BERRY, 1902: Early fossil *Liriodendron* leaves less cut; more nearly resemble those of *Magnolia*. — DANDY, 1927: BH four genera: *Talauma, Magnolia, Manglietia* and *Michelia;* at least *Aromadendron* must be added; favors adding also *Kmeria,* fls. unisexual; *Elmerilla* and *Michelia,* fls. axillary; and *Pachylarnax* with only 2-3 carpels, concrescent. — McLAUGHLIN, 1933; HUTCHINSON in 1921 separated *Magnoliales* from *Ranales;* wood anatomy indicates *Himantandra* is near *Annonaceae; Lactoris* should be in *Piperales; Illicium, Tetracentron* and *Euptelea* should each be monotypic family. — WHITAKER, 1933: *Tetracentron, Drimys, Cercidiphyllum, Trochodendron, Magnolia* and *Liriodendron* should be one group; they agree in nodal anatomy and in chromosome number, which is 19. — BAILEY, NAST and SMITH, 1943: *Degeneriaceae, Magnoliaceae,* sensu stricto, and *Himantandraceae* form a compact group within *Ranales;* among its characters are spherical secretion cells, sclerenchymatous medullary diaphragms, stratified phloem, wood fibers with small bordered pits, superficial origin of periderm, monocolpate pollen, stomata with subsidiary cells parallel to guard cells; *Winteraceae, Illicium, Schizandraceae* and *Tetracentron* only remotely related to this group.

5. HIMANTANDRACEAE

Aromatic trees; e. Australia, New Guinea, Moluccas; gen. 1.

Vessels present, perforations simple. Branchlets and lower leaf surface with peltate scales, leaves exstipulate. Petiole node tri-lacunar. Fl. parts spiral. Outer parts ovate to lanceolate, followed by narrow petal-like parts and staminodes, then about 40 sts., much like petals and staminodes, but with two anthers near base, no connective differentiated. Carpels about 8, slightly connate at base, 1 or 2 ovules in each, pendulous from apex, no funicle. Fl. globose, about 8-celled by coalescence of carpels. Seed with small embryo, endosperm oily.

TH sub *Annonaceae*. — DIELS, fam., 1917.

6. SCHISANDRACEAE

Climbing or trailing shrubs, *Illicium* a tree; s. e. Asia and Malayan Region, s. e. U. S.; gen. 3; *Schisandra, Kadsura, Illicium.*

Vessels present, perforation plate scalariform to simple porous. Lvs. with pellucid dots, exstipulate. Dioec. except *Illicium.* Sepals and petals similar. Sts many, carpels many, each with 2-3 ovules. Fr. a capsule or berry. Embryo small, endosperm abundant, oily. — *Illicium* sepals 3 or 6, petals many, ovule 1.

BH, TH sub *Magnoliaceae.*—*Schizandraceae* of HUTCHINSON, who placed *Illicium* with *Winteraceae.*

7. ANNONACEAE (Custard Apple Family)

Trees and shrubs, some climbing, widely distributed, Tropics and Subtropics; gen. 80; *Annona* (cherimoya, sweetsop, soursop.)

Bark with reticulate appearance. Fls. mostly perfect, sepals usually 3, separate or partly united; petals often 3+3; base of petals connate in *Hexalobus*. Sts. many, spirally arranged, or 3+3, filaments short, connective projecting, anthers extrorse. Carpels many or few, rarely united, styles separate, short thick; carpels usually stipitate in fr. Ovules basal or parietal, seeds often with aril. Embryo small; endosperm abundant, ruminate. — Very natural family; floral number 3; pollen development and bracts suggestive of monocotyledons; some resemblance to *Aristolochiaceae* (SAMUELSON, 1914). — *Monodora* carpels united, plac. parietal. — BH 2, TH 98.

8. EUPOMATIACEAE

Shrubs; New Guinea and Australia, gen. 1.

Lvs. alt., simple, exstipulate. Fls. perigynous, solitary; receptacle fleshy, dilated, adnate to base of calyx. Sepals and petals not clearly differentiated, forming a deciduous hood. Perianth and sts. perigynous. Sts. many, inner ones sterile, petaloid, outer ones with extrorse anthers. Carpels many, immersed in receptacle (*cf. Nelumbo*). Fruit a berry, several celled, seeds 1-2 in each cell; seed angular; embryo small, endosperm abundant, ruminate.

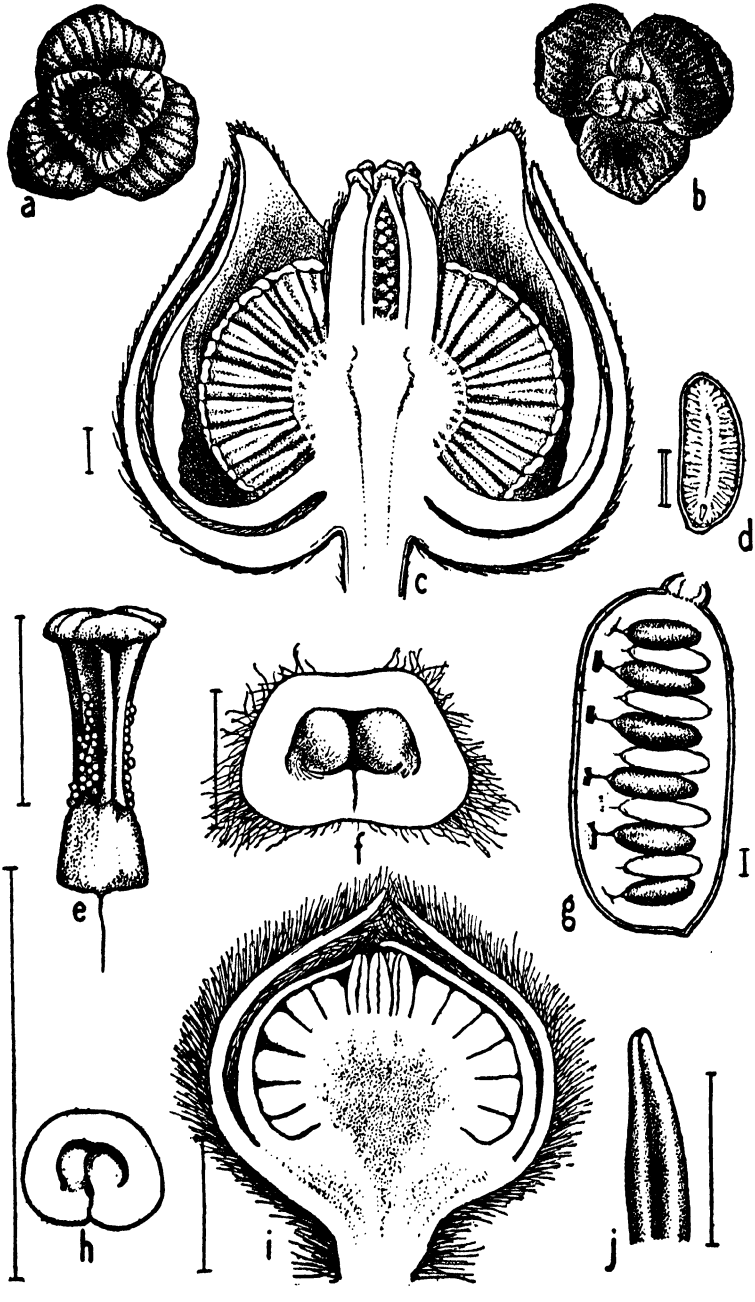
BH, TH sub *Annonaceae*. — DIELS, 1916: Beetles on *Ranales* fls. may have phylogenetic significance; *Eupomatia* has beetle pollination, according to DELPINO; also *Calycanthus* and *Magnolia;* quotes RATTRAY, 1913, stating beetles lay eggs on ovules of the Cycad, *Encephalartos*. — LEMESLE, 1936: Scalariform vessels and floral characters indicate *Eupomatiaceae* as most primitive family of *Polycarpicae*.

9. MYRISTICACEAE (Nutmeg Family)

Trees; throughout Tropics, chiefly Asia; gen. 10.

Lvs. entire, aromatic, often with pellucid dots. Dioec., fls. small, apetalous. Calyx 3-lobed. Sts. 2-30, filaments form column. Ovary 1-celled, stigma subsessile, ovule 1, almost basal. Fr. fleshy; seed with aril, often colored, cotyledons sometimes connate; endosperm abundant, mostly ruminate.

BH 141, TH 99. — GARRATT, 1933: Anatomy of wood near that of *Lauraceae*, more distant from *Magnoliaceae;* not like *Menispermaceae; Eupomatiaceae* wood not like *Annonaceae*. Secondary xylem uniform in family, all spp. have tanniferous tubes; occasional compound scalariform perforations.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10. CANELLACEAE

Trees with aromatic sap; Trop. Am. and Afr.; gen. 4.

Lvs. glabrous, gland-dotted, exstipulate. Fls. cymose, bracts 3, persistent. Sepals 4-5, thick; petals 4-12, free or connate. Sts. up to 20, filaments connate, making a tube; anthers extrorse. Ovary 1-celled, placentae 2-5, parietal; style thick. Fr. a berry. Embryo small, endosperm oily. — According to WARBURG, also WETTSTEIN, family should be next to *Myristicaceae.*

BH 16, TH 197. — GILG, Pflfam. 1925: L. DE JUSSIEU placed *Canellaceae* with *Meliaceae,* because of connate sts. Oil-cells and bordered pits like *Magnoliaceae;* in *Cinnamodendron* spirally arranged petals. *Myristicaceae* doubtless in *Ranales,* but also near *Canellaceae; Flacourtiaceae* resemble *Ranales* in many ways, for example, through *Oncoba.* — VESTAL, 1937: Anatomy indicates *Canellaceae* should be near *Myristicaceae.*

11. CALYCANTHACEAE (Strawberry Shrub Family)

Shrubs in s. e. U. S., Calif., China; 1 sp. in Australia; gen. 2.

Vessel perforations simple. Oil cells present. Lvs. opp., entire, exstipulate. Fls. spiral, perianth parts many, colored. Sts. 10-20, anthers adnate and extrorse. Carpels about 20, free in cup-shaped fl. axis, each with 2 anatropous ovules. Seed coats 2; cotyledons large, spirally rolled, nearly filling seed. Frs. enclosed in enlarged floral axis. — HUTCHINSON near *Rosaceae.*

BH 3, TH 96.

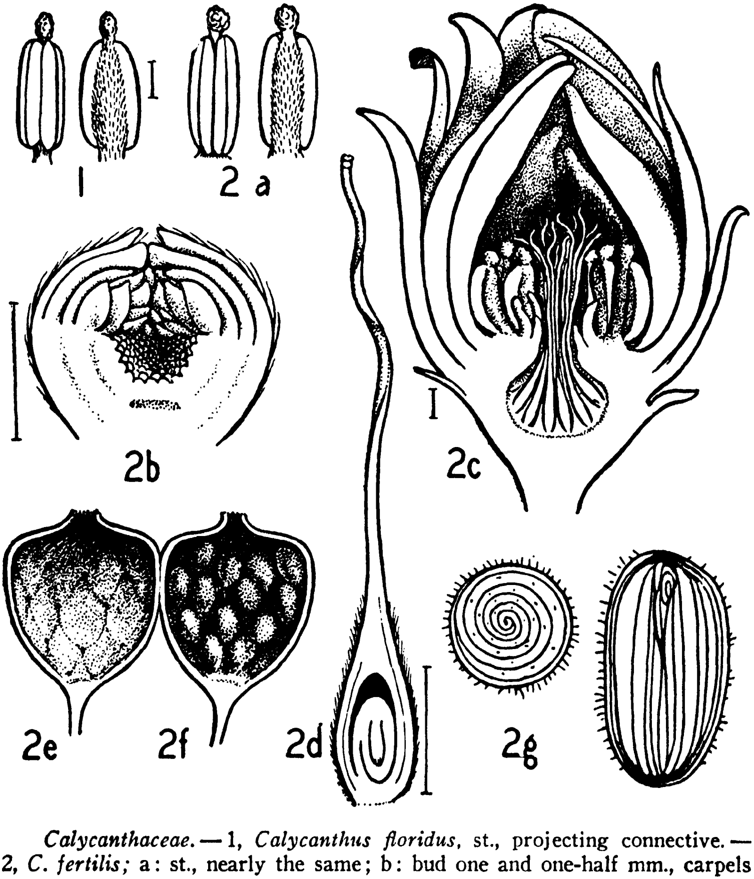
12. MONIMIACEAE

Trees and shrubs, usually fragrant; Tropics and Subtropics, many South of Equator; gen. 30; *Atherosperma,* large Australian timber tree.

Lvs. usually opp., leathery with pellucid oil cells, exstipulate. Fls. mostly small, unisexual. Perianth parts 4-many, separate, if many, inner ones petaloid. Sts. and carpels inside hollow receptacle; sts. usually many, spiral, anther dehiscence sometimes valvate. Carpels usually many, sunken in receptacle, each with 1 ovule. Fruits enclosed in enlarged receptacle. Embryo small in endosperm, not ruminate.

Annonaceae. — *Asimina triloba;* a: fl. from above, three large, three smaller petals, many stamens and carpels; b: from below, outer petals and three sepals, base connate; c: fl., sts. with short filaments, carpels with sessile stigmas; d: seed two cm., endosperm ruminate, embryo very small; e: st. covered by dilated top of connective (*cf. Platanus*); f: sec. ovary; g: long. sec. fruit; h: sec. young ovary; i: sec. fl. bud, two mm.; j: young carpel.

BH 142, TH 101. — Perkins and Gilg, Pflreich. 1901: Family distinct, nearest *Lauraceae* and *Calycanthaceae*. — Garratt, 1934: Perhaps near *Lauraceae;* some resemblance to *Myristicaceae, Magnoliaceae* and *Calycanthaceae.*



Calycanthaceae. — 1, *Calycanthus floridus*, st., projecting connective. — 2, *C. fertilis;* a: st., nearly the same; b: bud one and one-half mm., carpels slightly sunken; c: fl., fifteen mm., small bracts, sepals and petals hardly differentiated; sts., anthers extrorse, small staminodes, carpels deeply sunken, styles long (*cf. Rosa*); d: single carpel, anatropous ovule; e: inside wall of false fr., showing akene attachments; f: akenes surrounded by false fruit; g: seed with broad cotyledons spirally rolled, no endosperm (*cf. Rosa*).

13. GOMORTEGACEAE

Tree; Chile; sp. 1.

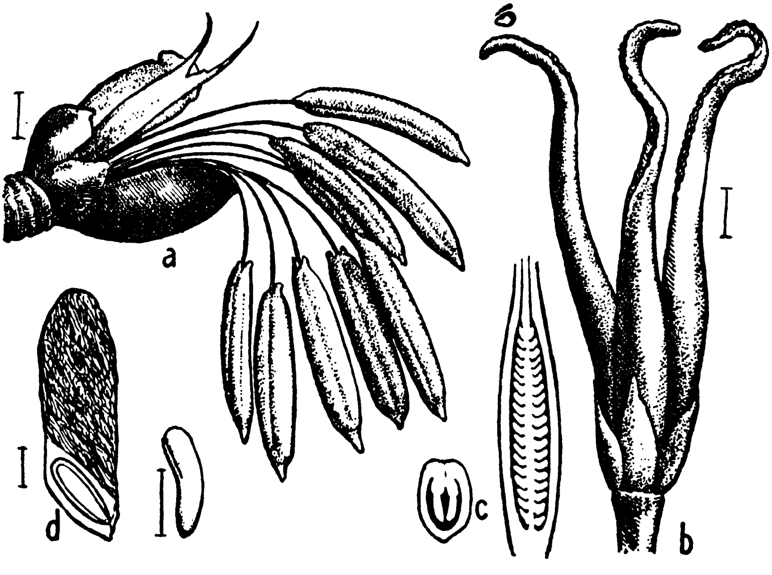
Lvs. opp., aromatic, exstipulate. Sepals 7-10, spiral, petals none. Fertile stamens 2-3, anthers opening by valves. Ovary inferior, 2-3 celled; ovule pendulous, 1 in each cell; style short, 2-3 parted. Embryo large, endosperm oily.

BH sub *Lauraceae,* TH 100. — Fam. Reiche, 1896.

14. LAURACEAE (Laurel Family)

Trees and shrubs; rarely twining, parasitic herbs; in Tropics and Subtropics, especially s. e. Asia and Brazil; gen. 40.

All parts with aromatic oil glands. Lvs. usually alt., leathery with pellucid dots, exstipulate. Calyx 6-lobed, imbricate. Sts. 4-3 whorls; anthers mostly introrse, continuous with filament, 2-4 valved. Ovary 1-celled, stigma small, ovule 1, pendulous. Cotyledons thick, seed coats 2; endosperm none.



Cercidiphyllaceae. — *Cercidiphyllum japonicum;* a: bracts with sts., filaments slender, anthers red, connective projecting; b: carp. fl. of three (or more) separate carpels, long purple styles, sepals 4; c: sec's. ovary; d: seed winged, embryo slightly curved.

BH 143, TH 102. — Coy, 1928: *Sassafras* one of earliest known fossil angiosperms, implying a much more ancient history.

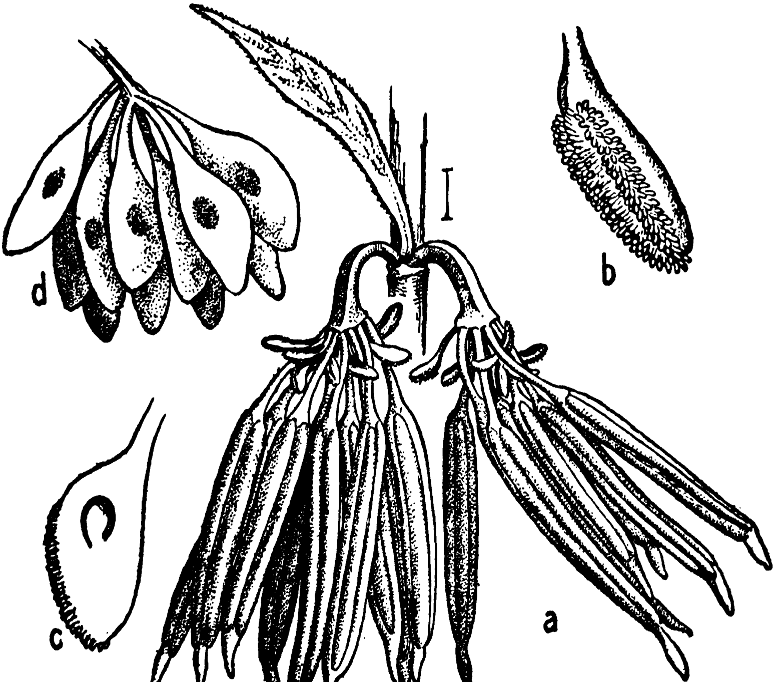
Subfam. ? *Hernandioideae* (*Hernandiaceae,* fam. Dumortier, 1829; BH sub *Lauraceae,* TH 103).

Trees and shrubs; Tropics, gen. 4. Wood spongy; lvs. simple or palmately compound, exstipulate. Sepals usually 3-5 in 2 whorls. Sts. 3-5, anthers opening by 2 valves, staminodes gland-like or none. Ovary inferior, 1-celled; ovule 1, pendulous, endosperm none. — *Gyrocarpus,* cotyledons spirally coiled.

15. CERCIDIPHYLLACEAE

Cercidiphyllum, large timber tree in China; Japanese variety lower, usually branching from base; sp. 1.

Lvs. usually opp., stipules adnate to petiole. Dioec. Sepals 4, separate, small; petals none Sts. 15-20, united at base, anthers red, filaments long, projecting. Carpels 4-6, slightly stipitate, styles long, stigmatic on inside, ovules in 2 rows. Fruit a follicle; seeds winged; embryo medium size; endosperm abundant. — Near *Hamamelidaceae?* — TH 90a.



Eupteleaceae. — *Euptelea Franchetti;* a: bract ciliate, fl. cluster, no perianth, sts. many, anthers long, red, connective projecting, carpels separate, small, stipitate; b: carpel with decurrent stigma; c: sec. ovary with single ovule (or few); d: cluster of winged fruits.

16. EUPTELEACEAE

Shrubs or small trees; China and Japan; gen. 1.

Vessel perforations scalariform. Lvs. alt., petiole long, no aromatic cells. Fls. in axils of bracts, perianth none. Sts. many, anthers red, with projecting connective; pollen tricolpate to polycolpate. Carpels many, separate, stipitate, with decurrent stigma, developing after sts. have dropped. Fr. winged, 1 to 4 seeds. Seed small, anatropous, seed coats 2. Embryo small, endosperm abundant. — Position doubtful.

TH 90. — VAN TIEGHEM, *Euptéléacées,* 1900. — NAST and BAILEY, 1946.

17. NYMPHAEACEAE (Waterlily Family)

Water plants or marsh plants; cosmopolitan; gen. 8.

Lvs. peltate or cordate, floating or submerged, latex sometimes present. Fls. large, solitary. Perianth parts 6-many, sepals usually distinct. Ovules 1-many on inner walls of carpel, laminal, seed coats 2. Seed usually with perisperm and endosperm, often with aril.

Cabomboideae (*Cabombaceae* of GRAY, of HUTCHINSON). Fls. small, cyclic. Sepals 3, petaloid, petals 3, sts. 3-6, carpels separate.

Nelumbonoideae. Fl. parts spiral; carpels immersed in receptacle.

Nymphaeoideae. Carpels fused, stigma *Papaver*-like. Sepals 4. In *Nymphaea* numerous petals, spiral from sides of ovary, pass gradually into numerous sts.; *Euryale* and *Victoria,* ovary inferior.

BH 8, TH 88. — TROLL, 1933: All laminal placentation except *Victoria* and *Euryale,* these have epeltate carpels. *Ceratophyllum* may be reduced type near *Nymphaeaceae.* — ZAZHURILE and KUZNETSOVA, 1939: Placentation diffuse.

RANALES

Herbaceous plants or shrubs with soft wood, lvs. often compound, fls. often 3-parted.

Chromosomes:

Berberidaceae — *Nandina* 5; *Diphylleia, Epimedium, Jeffersonia, Podophyllum* 6; *Berberis* 7 or 14.
Lardizabalaceae — *Lardizabala* 28, *Akebia* 32, *Decaisnea* 30.
Menispermaceae — *Menispermum* 13, *Cocculus* 13, 19.
Ranunculaceae — *Paeonia* 5; *Nigella, Thalictrum* 6, 7; *Anemone, Aquilegia, Ranunculus* 7, 8; *Actaea, Adonis, Aconitum, Clematis, Delphinium, Helleborus* 8, *Xanthorhiza* 9.

18. RANUNCULACEAE (Buttercup Family)

Mostly perennial herbs, some annuals, few shrubs (*Xanthorhiza, Paeonia suffruticosa*) or woody climbers (*Clematis*), chiefly in temperate and cold climates; gen. 30; *Delphinium* (larkspur), *Paeonia, Adonis,* and other garden plants.

Vascular bundles of *Actaea, Thalictrum* and others suggest monocotyledons. Lvs. radical or alt., in *Clematis* opp., some 3-parted, stalks dilated at base. Fls. spiral or spirocyclic, rarely cyclic, a few zygomorphic (*Delphinium*). Perianth single or double, nectar glands common. Sts. usually many. Carpels many, few or rarely 1; ovules many or few in each carpel, anatropous. Fr. of follicles or akenes, rarely a berry. Embryo small, cotyle-

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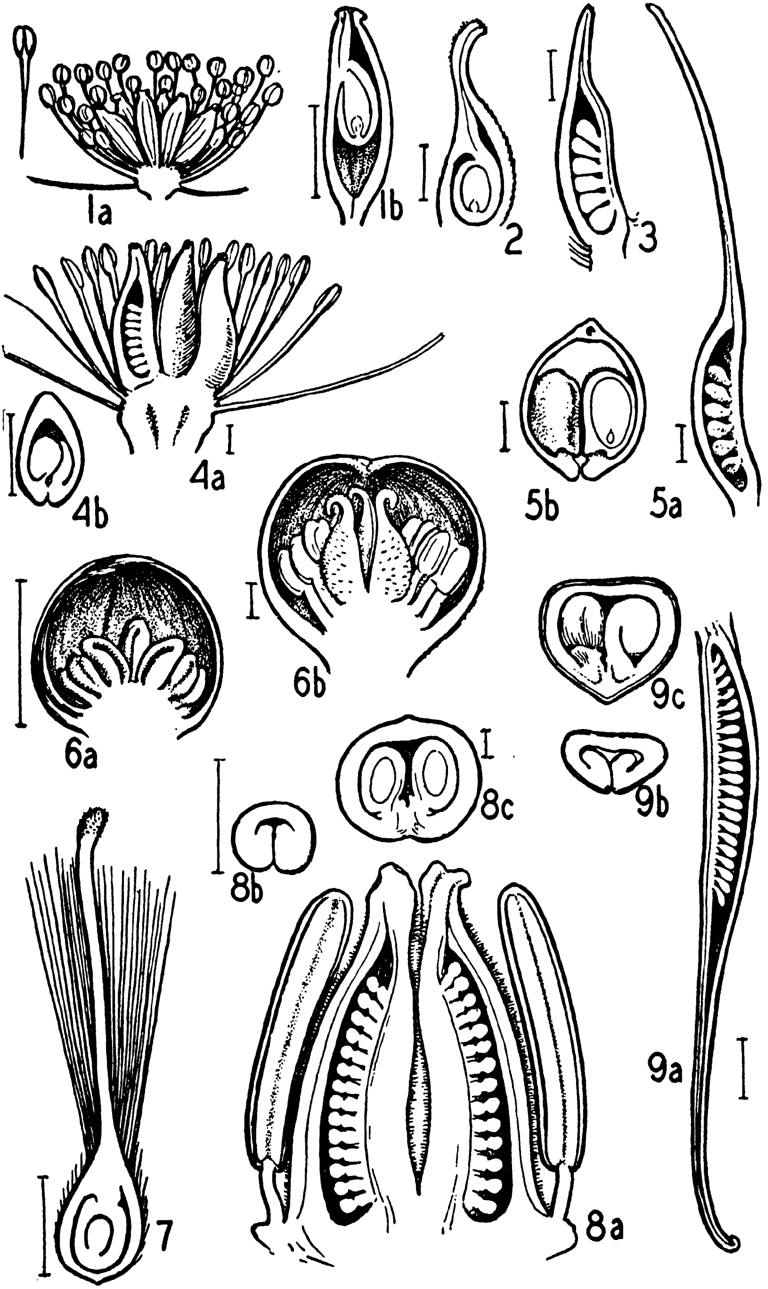
Ranunculaceae. — 1, *Anemonella thalictroides;* a: fl., sepals thin, sts. many, filaments long, wider above, carpels several, separate, stigma sessile; b: ovary with single suspended ovule, embryo small, in endosperm. —2, *Anemone nemorosa,* carpel and ovule. — 3, *Trollius laxus,* carpel with several ovules. — 4, *Caltha palustris;* a: fl., sepals thin, connective conspicuous, stigma sessile; b: sec. ovary. — 5, *Helleborus orientalis;* a: sec. carpel; b: cross sec. ovary, two rows ovules, small embryo in endosperm. — 6, *H. foetidus;* a: bud one mm., sts. and carpels slightly differentiated; b: bud five mm. — 7, *Clematis Jouiniana;* carpel, single ovule, style plumose below. — 8, *Paeonia decora;* a: sec. young ovary, sts. short filaments, carpels partly open, ovules many; b: sec. very young ovary, half mm.; c: adult ovary, five mm. — 9, *Aquilegia flabellata;* a: single carpel; b: sec. young carpel; c: later, ovules anatropous.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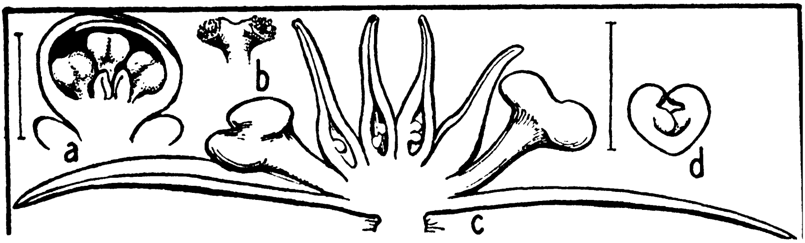
dons sometimes connate at base; seed coats 2 or 1; endosperm abundant. No nectar glands in *Paeonia, Clematis, Anemone, Thalictrum.*

Paeonia (*Paeoniaceae,* WORDSELL, 1908). Fls. solitary, sepals and petals distinct, disk present, outer seed coat strongly developed as in *Berberidaceae;* sts. suggest *Magnolia.*

BH 1, TH 91. — SALISBURY, 1926: In *Helobiales* and *Ranunculaceae* three-parted fls. are primitive, explained by division of meristen derived from three-sided apical cell. — SMITH, G. H. 1926 and 1928: Vascular anatomy suggests *Menispermaceae, Calycanthaceae, Annonaceae* may be offshoots from *Ranunculaceae.* — CHUTE, 1928: Akene in *Ranunculaceae* and *Rosaceae* derived from follicle by reduction; sometimes traces occur to suppressed ovules. — EARLE, 1938: In *Magnoliaceae, Ranunculaceae* and *Berberidaceae* embryo at first pear-shaped; cotyledons symmetrical. In *Nymphaeaceae* and *Ceratophyllaceae* cotyledons come from common primordium; embryo is asymmetrical. — KUMAZAWA, 1938: From systematic and phylogenetic considerations favors *Paeoniaceae, Nandinaceae, Podophyllaceae* as families. — BENSON, L., 1940: N. Am. *Ranunculus* species have six types of nectary scales, characterizing subgenera and sections. — GREGORY, 1941: Comparison of chromosomes and of floral morphology indicates *Paeonia* as primitive genus; *Adonis* and *Ranunculus* next; separate vascular bundles and frequently 3-parted fls. in family suggest monocotyledons; polyploidy may play a significant role in some genera, not in others. *See* page 22.



Ranunculaceae. — *Xanthorhiza apiifolia;* a: bud carp. fl., one mm., bracts, sepals, club-like nectaries, carpels; b: st., connective prominent; c: fl., brown sepals, nectaries, carpels with two ovules; d: sec. young carpel.

19. CERATOPHYLLACEAE (Hornwort Family)

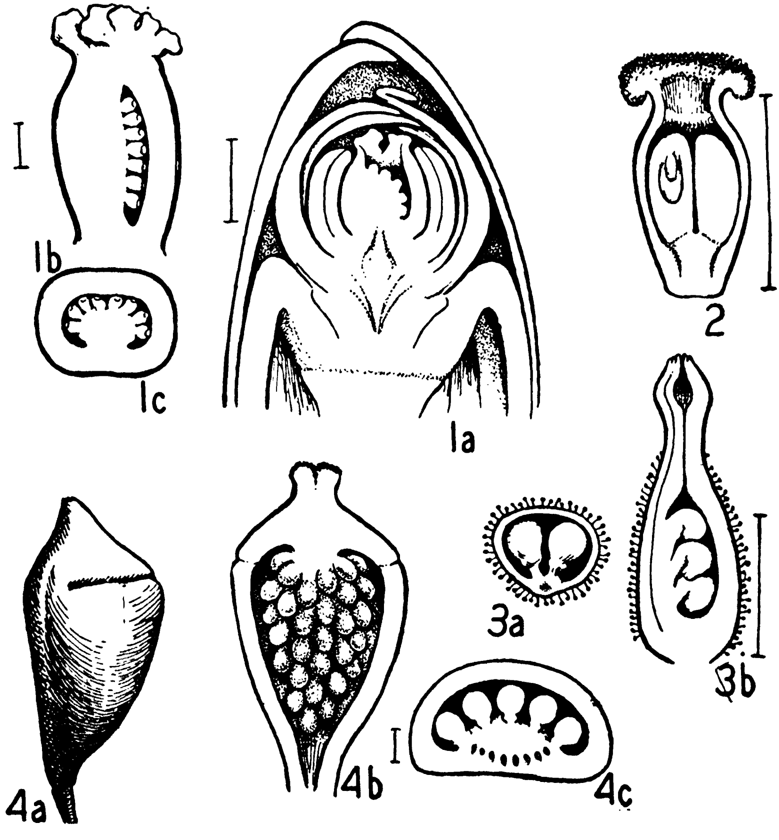
Rootless submerged plants in still, fresh water; cosmopolitan, except Arctic; gen. 1.

Lvs. dissected in whorls. Fls. solitary, small, axillary, monoec. Perianth single with tubular base, 12 lobes. Ste. fls. whitish; sts. 12-16, spiral, filaments very short, fleshy connective projecting. Carp. fls. greenish; carpel 1, style long, ovule 1, orthotropous, pendulous from top. Fr. akene with persistent style. Seed with large, highly developed embryo, endosperm none; seed coat 1.— BH 163, TH 89.

20. BERBERIDACEAE (Barberry Family)

Shrubs and perennials, mostly in N. Temp.; gen. 10.

Lvs. simple or compound. Fls. usually 3-parted, perianth 2-4 whorls, usually differentiated into sepals and petals. Often 2 whorls of nectar-glands, sts. mostly 3+ 3, anthers often with val-



Berberidaceae.—1, *Podophyllum peltatum;* a: bud with bracts, sepals, petals, sts., ovary with leaflike stigma; b, c: ovary, later.—2, *Berberis vernae;* stigma circular, hollow, ovules few.—3, *Epimedium macranthum;* sec. young ovary, glandular hairs.—4, *Jeffersonia diphylla;* a: fr. with lid; b: ovary, two-lobed stigma, plac. lateral; c: cross sec.

vate dehiscence. Carpels usually 1, style short or none; ovules many to few, or 1 ovule at base. Embryo small, seed coat 2, aril sometimes present. — *Podophyllum* many sts., no nectaries; carpels sometimes remain open.

BH 7, TH 93. — JOHRI, 1935: Embryology indicates *Berberis* near *Ranunculaceae;* should be in same order. — CHAPMAN, 1936: From carpel morphology concludes *Berberidaceae* is parallel to, rather than derived from, *Ranunculaceae.*

Circaeaster? (*Circaeasteraceae,* fam. POST and KUNTZE, 1903; of HUTCHINSON; DIELS sub *Ranunculaceae.*) Small annual; N. W. Himalaya, China. Sepals 2, membranous, no petals; sts. 2. Ovary 1-celled, stigma sessile; ovule 1, pendulous; endosperm abundant.

21. LARDIZABALACEAE

Mostly climbing shrubs; *Decaisnea* tree-like shrub; e. Asia, Chile; gen. 7.

Wood with broad primary medullary rays, no oil cells; lvs. palmately or pinnately compound, petiolules usually swollen at base. Monoec. Sepals 3-6, often colored, petals small, 3+3, or none. Sts. 3+3, often connate, anthers extrorse, connective often projecting. Carpels 2-3, when mature flesh-colored. Seeds many, seed coats 2, embryo small, endosperm abundant. Sts. suggest *Asarum* (*Aristolochiaceae*). — TH 92.

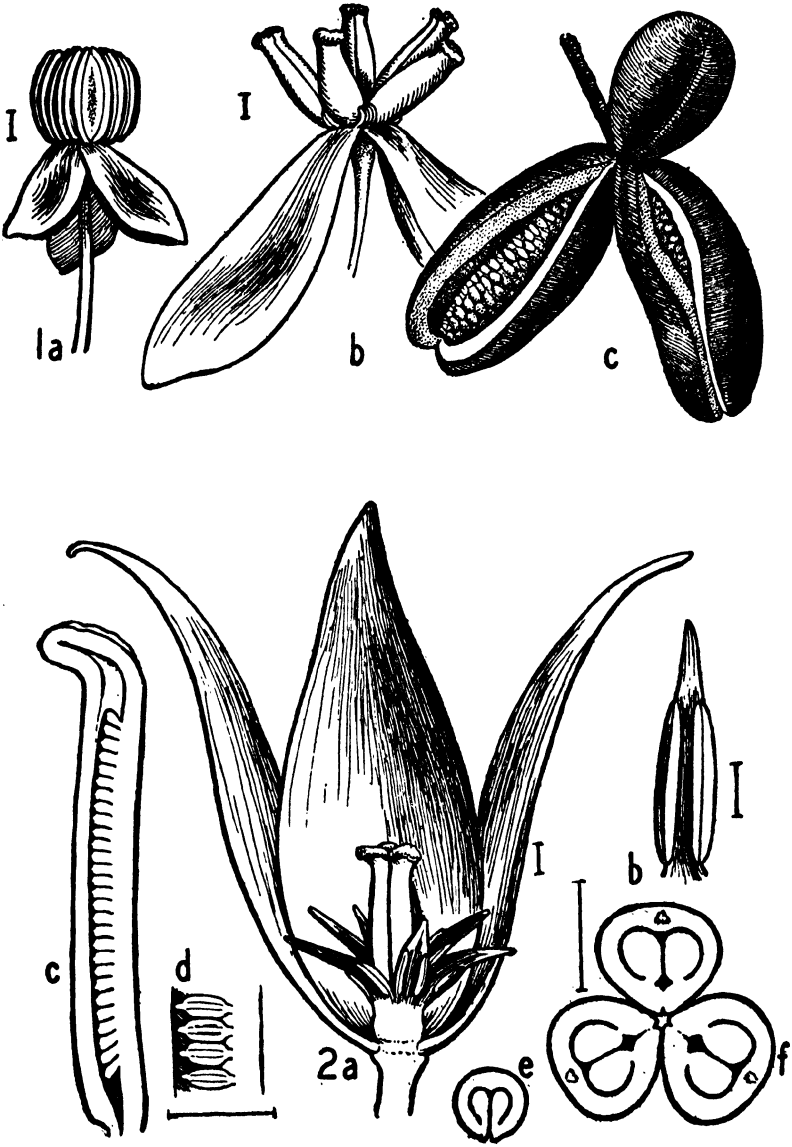
Sargentadoxa (STAPF as fam.; DIELS sub *Ranunculaceae*). Climbing shrub, China. Sepals 6, petals 6. Sts. 6, opp. petals; connective projecting. Carpels many, spirally arranged, each with 1 ovule, pendulous. Fr. a berry; embryo small, endosperm abundant.

22. MENISPERMACEAE (Moonseed Family)

Twining or rarely erect shrubs or small trees; mainly Tropics and Subtropics; gen. 80.

Wood with broad medullary rays. Lvs. often palmately lobed, rarely 3 lflts; exstipulate. Fls. small, dioec. 2 whorls each of sepals, petals and sts. Petals smaller than sepals, sometimes connate, or none. Sts. 6, 3 or many, often a column (*Cissampelos*). Carpels mostly 3, sometimes many. Fruit a drupe; fruit and seed curved; endosperm little.

BH 6, TH 94. — DIELS, Pflreich. 1910: Decaisne separated *Lardizabalaceae* from *Menispermaceae.* Close conformity in fls. of *Euphorbiaceae* with *Menispermaceae*: sts. often identical, free or united; carpels much resemblance; style canal of *Euphorbiaceae* in some *Menispermaceae; Euphorbia*-like fl. of *Odontocarya;* peltate ovules of *Clochidion* and related genera; *Euphorbiaceae* often with curved seeds; relationship unmistakable.



Lardizabalaceae. — 1, *Akebia quinata;* a: ste. fl., three sepals, six sts., anthers extrorse, sessile; b: carp. fl., larger sepals, small staminodes, five carpels, stigmas sessile; c: fr. purplish, fleshy pods, numerous seeds. — 2, *Decaisnea Fargesii;* a: fl. six sepals, six sts., filaments connate, anthers extrorse, stigmas sessile; b: st. with prominent connective; c: carpel; d: ovules; e: single young carpel; f: sec. ovary.

PIPERALES

Vascular bundles often separate. Fls. small, usually 3-parted, in dense spikes, perianth absent. Embryo small, endosperm and perisperm.

Chromosomes:
Chloranthaceae — Chloranthus 7, 15.
Piperaceae — Peperomia, Piper 8, 12.

23. LACTORIDACEAE

Shrubs, Juan Fernandez I.; gen. 1.

Vessel perforations simple. Lvs. alt., small, emarginate, with pellucid dots; stipules relatively large. Fls. polygamo-monoecious, small, sepals 3, petals none. Sts. 3 + 3; anthers extrorse, connective projecting. Pollen development suggests monocotyledons. Carpels 3, free. Fr. follicular, embryo small, endosperm oily. — TH 97. — SKOTTSBERG, Pflreich.

24. SAURURACEAE

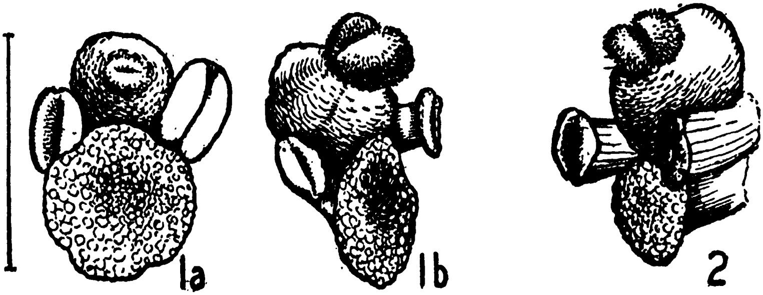
Perennial marsh herbs; n. e. Am., Calif., and s. e. Asia; gen. 3.

Stems jointed, lvs. alt., cordate, entire, with sheathing petioles or with intrapetiolar sheath. Fls. on small bract in dense spikes, perianth none. Sts. 6-7, lower part sometimes adnate to carpels. Carpels 3-4, united at base, plac. parietal. Ovules few. Fr. somewhat fleshy. Embryo small, endosperm little, perisperm abundant. — TH 52.

25. PIPERACEAE (Pepper Family)

Herbs and shrubs, often climbing; rarely trees. Distribution wide, nearly all tropical; gen. 9; *Piper, Peperomia.*

Vascular bundles scattered in 2 or 3 whorls. Oil cells present. Lvs. often succulent, entire, with sheathing petioles. Fls. small, usually in fleshy spikes. Perianth usually none. Sts. 2, 3, 6 or many, filaments short, anthers extrorse. Ovary 1-celled, stigmas often 3; ovule 1, basal, orthotropous. Embryo small, endosperm little, perisperm abundant. — BH 139, TH 53.



Piperaceae. — 1, *Peperomia Saundersi,* no perianth; a: two sts., one large bract (or staminode?), young ovary; b: later, side view, thick filament, ovary with sessile, fringed stigma. — 2, *P. peltifolia.*

26. CHLORANTHACEAE

Small trees, shrubs, rarely herbs; Trop. Am., e. Asia, Pacific Is.; gen. 3.

Vessel perforations scalariform; lvs. aromatic, opp., petioles united by sheath. Fls. small, perfect or unisexual, usually in spikes, each fl. subtended by bract; perianth single, none on ste. fls. Sts. in perfect fls. from top of ovary, anthers introrse. Ovary inferior, 1-celled, stigma usually sessile, ovule 1, suspended, orthotropous. Fr. a drupe; perisperm abundant. — BH 140, TH 54. Several characters suggest *Gnetum.*

CACTALES

Single family.

Chromosomes:

n: 11; except *Pereskia* and *Zygocactus* 12.—STOCKWELL, 1935; 2n, *Opuntia* 22, 66, 44; in *Cereeae* 22, 44, 18, 24.

27. CACTACEAE (Cactus Family)

Succulent spiny plants, nearly all American, from 60° N. in Canada, S. to Patagonia; a few *Rhipsalis* in Afr.; *Opuntia* naturalized in Medit. and S. Afr.; gen. 25 (Pflfam.), 50 (BERGER), 150 (BRITTON and ROSE).

Fls. sessile, usually solitary, often large. Sepals and petals spirally arranged, not clearly distinct. Sts. numerous, spiral, from floral tube. Ovary inferior, 1-celled. Plac. basal in *Pereskia,* otherwise parietal. Style single, hollow, that is, ovary open; stigmas several. Seeds many, embryo usually curved, seed coats 2, endosperm little. Three subfamilies: 1. *Pereskioideae:* trees, lvs. flat, fls. stalked, perianth parts few, sepals separate or nearly so. 2. *Opuntioideae:* stems usually leaflike, flattened; lvs. small, soon falling. 3. *Cereoideae:* stems simple or much branched, usually strongly ribbed; lvs. usually only as scales on ovary or floral tube; fls. more or less tubular.—Family characters suggest *Nymphaeaceae,* also *Myrtaceae* and *Aizoaceae;* possibly related to all three.

BH 78, TH 210.—DE FRAINE, 1910: *Pereskia* seedlings have no sign of succulence.—ARBER, 1910: *Cactaceae* seedlings and floral type suggest family may be near *Nymphaeaceae.*—POHL, 1922: *Cactus* has fleshy aril developed from funiculus; berry in *Garcinia* largely from aril; compare *Podophyllum* (*Berberidaceae*).—BRITTON & ROSE, 1919-23: Four vol's, extensively illustrated, begin with *Pereskia.*—VAUPEL, Pflfam. 1925.—CHORINSKY, 1931: Hair structures of *Anacampseros* (*Portulacaceae*) has several details in common with those of *Cactaceae.*—NEWMANN, 1935: *Pereskia* many characters of *Centrospermae:* secretory tapetum, similar division pollen in other cells, trinucleate pollen, ovules crassinucellate, integ. 2; micropyle formed by inner integument.

CISTALES

Fls. 5-parted, sts. 5-many, carpels usually 3, plac. parietal, endosperm usually present.

Chromosomes:

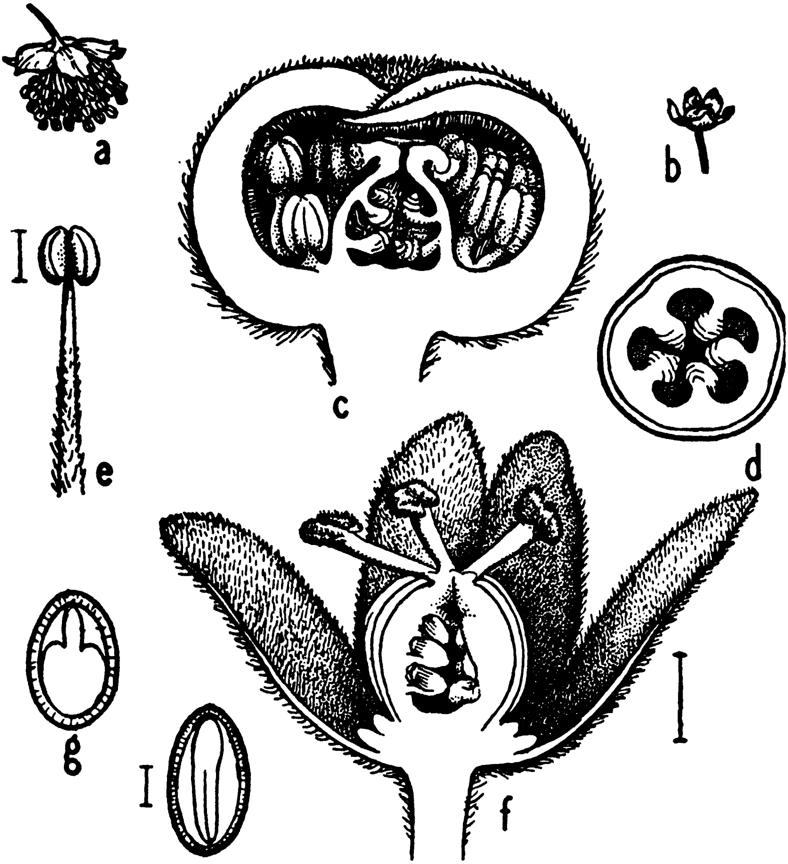
Begoniaceae — *Begonia* 6, 7, 9.
Bixaceae — *Bixa* 7.
Cistaceae — *Helianthemum* 8, 10, 12; *Cistus* 9.
Cucurbitaceae — *Cucumis* 7, 12; *Cyclanthera* 8, *Thladiantha* 9, *Bryonia* 10, *Lagenaria, Momordica* 11; *Cucurbita* 10, 12; *Sechium, Benincasa, Ecballium* 12.
Datiscaceae — *Datisca* 11.
Flacourtiaceae — *Hydnocarpus* 11, 12.
Loasaceae — *Loasa* 7, 15; *Blumenbachia* 12.
Passifloraceae — *Passiflora* 9; *Carica* 9.
Violaceae — Clausen, 1927: Great diversity in chromosome number in genus *Viola;* three principal series: a 6, a 12, and a 10, series.

28. FLACOURTIACEAE

Trees, often tall, and shrubs; many Afr., also Trop. Asia and S. Am., few in Australia; gen. 70; *Taraktagenos* (or *Hydnocarpus*), source of chaulmoogra oil; some tropical fruits.

Lvs. mostly alt., leathery, often with long petiole and nectaries; stipules small, falling early. Fls. usually small, mostly bisexual. Fl. structure varies. Sepals 2-6-15, imbricate; petals none or equal to sepals, imbricate. Receptacle enlarged and modified; often with disk. Sts. usually many. Ovary 1-celled, carpels 2-10, placentae parietal; style and stigma 1 to several, ovules many. Seed coats 2, aril frequent, embryo straight, endosperm present. — Family much diversified: in *Soyauxia* scalariform vessels, corona; *Oncoba,* fls. large, sweet-scented; *Pangium, Flacourtia* and others unisexual; *Erythrospermum* and others, sepals and petals spiral; *Dissomeria* with inner whorl of petals; *Monadendron* apetalous, st. 1; *Casearia, Samyda* and others, fls. perigynous; *Bembicia* ovary inferior, *Homalium* half inferior. — BH 71, TH 199.

Lacistema (*Lacistemaceae* BH 161, TH 55). Shrubs or small trees gen. 1, Trop. Am. Fls. small, sepals 3 + 3 or none. St. 1, on hollow disk; anther cells often stipitate. Ovary 2-3 parietal placentae, style 1, stigmas 3. Ovules 1-2 on each placenta, pendulous on long funiculi. Capsule 1-seeded, seed coats 2, endosperm present.



Flacourtiaceae.—*Idesia polycarpa,* sepals usually 5; a: ste. fl.; b: carp. fl., both apetalous; c: perfect fl. bud; ovary not closed; d: sec. ovary, ovules orthotropous; e: st., filament pubescent; f: carp. fl., staminodes, ovules anatropous, styles 5, spreading; g: seed, embryo in endosperm (*cf. Passiflora, Cucurbita*).

KRAUSE, Pflfam. 1925: *Piperaceae* and *Lacistemaceae* have different anatomy and fls.; BAILLON, and recently CHIRTOIN, included *Lacistema* in *Flacourtiaceae,* because of fl., ovary, embryo.—GILG, Pflfam. 1925: *Flacourtiaceae* can hardly be separated from *Violaceae,* tribe *Alsodeieae* (inc. *Rinorea*); nor from *Turneraceae* and *Passifloraceae;* but these are such natural groups, it seems better to keep them separate. *Flacourtiaceae* probably ancient. *Stachyuraceae* with scalariform vessels, narrow medullary rays, chambered parenchyma, might be united with *Flacourtiaceae.*—BERGER, 1928: Wood anatomy confirms tribes grouping: *Erythrospermum* belongs with *Oncobeae;* much of wood structure can be seen with hand lens.—TUPPER, 1934: Wood anatomy of *Stachyuraceae, Passifloraceae, Violaceae,* and *Flacourtiaceae,* esp. rays, similar.— WETTSTEIN, 1935: Family near *Capparidaceae.*—TAYLOR, 1938: *Violaceae* and *Flacourtiaceae* form a unit within *Parietales;* that order lacks uniformity, but includes many primitive anatomical characters.

29. VIOLACEAE (Violet Family)

Herbs, shrubs and trees; widely distributed; gen. 15; *Rinorea* and others, woody, Tropics; *Viola,* herbaceous, mostly Temp.

Most tropical *Violaceae* have regular or nearly regular fls. Lvs. mostly alt., stipulate. Fls. sometimes cleistogamous. Sepals 5, separate or nearly so, persistent, petals 5, mostly unequal, 1 often larger and spurred. Sts. 5, sometimes slightly perigynous; anthers introrse, forming a ring around ovary; abaxial sts. often spurred at base, connective often projecting. Ovary 1-celled, placentae parietal, at carpel margins; style 1, stigma various; ovules many. Fr. a loculicidal capsule; seeds anatropous, cotyledons flat, endosperm present.—*Alsodeia, Hybanthus* sps., lvs. opp.; *Anchieta* and *Agatea,* climbers, seed winged.

BH 15, TH 198.—Melchior, Pflfam. 1925: A natural family, only *Leonia* peculiar; sts. few, floral axis always flat: nearest *Flacourtiaceae;* also near *Malesherbiaceae* and *Passifloraceae.*—Melchior, 1925, 1927, 1932: Family naturally begins with *Rinorea;* two lines from *Flacourtiaceae:* one to *Violaceae;* another to *Turneraceae*—*Malesherbiaceae*—*Passifloraceae;* but *Canellaceae, Stachyuraceae* and *Achariaceae* are isolated. Opposed to Hutchinson's group *Violales,* which includes *Resedaceae,* they have little in common with *Violaceae.* Multifl. infl. in *Viola* interpreted as reversion to primitive condition.

30. BIXACEAE

Shrubs and trees with colored sap; widely distr. in Tropics; gen. 4; inc. *Cochlospermaceae; Bixa,* seed coat source of annatto orange dye.

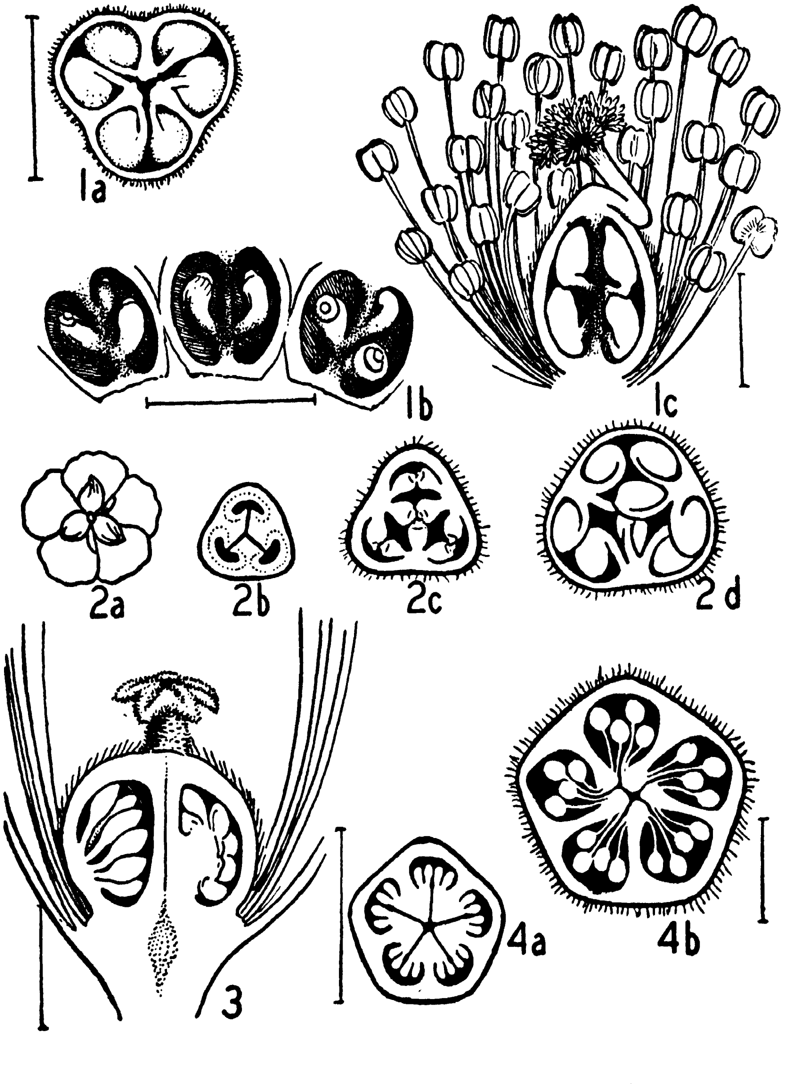
Lvs. alt., stipulate, palmately lobed except in *Bixa.* Fls. large, sepals 5, petals 5. Sts. many, with short, terminal, pore-like slits, in *Bixa* anthers horseshoe-shaped. Ovary one-celled, parietal placentae often protrude into cell, sometimes 3-celled; ovules many. Stigma 2-3 lobed. Fruit a capsule. Embryo curved in endosperm, cotyledons broad. Seed, in *Bixa* with orange-red testa, endosperm starchy, in *Cochlospermum* with long hairs, endosperm oily.

BH 17, TH 194, 195.—Pilger, Pflfam. 1925: *Bixaceae* and *Cochlospermaceae* near each other by oil-cells, form of anther, basal ovules.

31. CISTACEAE (Rockrose Family)

Herbs and low shrubs, chiefly Medit., some in N. Am.; gen. 7.

Lvs. simple, lower usually opp., upper alt.; with long one-celled hairs, in bundles appearing stellate. Fls. solitary or cymose, often large. Sepals 3-5, often unequal, petals 5, sometimes absent, sepals and petals contorted, soon falling off. Sts. many, free on



Cistaceae. — 1, *Helianthemum canum;* a: ovary, plac. parietal; b: young ovary spread open; c: sts. many, filaments slender, pistil with bent style (*cf. Cruciferae, Viola*), stigmas fringed. — 2, *Helianthemum Chamaecistus;* a: fl. under side, three large, two small sepals; b, c, d: ovary developing; b: no ovules; c: ovules, orthotropous; d: ovules anatropous. — 3, *Cistus lanifolius;* fl., carpels five, plac. parietal. — 4, *C. villosus,* placentae separate, that is, parietal; a: in bud, ovules sessile; b: adult, ovules on funiculi.

elongated or disk-like part of receptacle. Ovary 1-celled, plac. parietal, ovules 2 or more to each placenta on funicles, style with 3-5 stigmas. Fr. a loculicidal capsule, embryo often curved, cotyledons narrow, endosperm starchy. — *Lechea,* fl. 3-parted, embryo almost straight. — *Cistaceae, Tamaricaceae, Papaveraceae* visited by pollen-eating insects.

BH 14, TH 193. — GROSSER, Pflreich. 1903: Near *Bixaceae:* ENGLER included both in Suborder *Cistineae.* — JANCHEN, Pflfam. 1925: *Bixa* differs in larger lvs., 2-carpel ovary, imbricate sepals, anatropous ovules; *Cistaceae* near *Flacourtiaceae* and *Violaceae.*

32. TURNERACEAE

Herbs, rarely shrubs; Trop. Am., few in Asia, one in S. Afr.; gen. 7.

Lvs. alt., exstipulate; often with basal glands. Calyx tubular, 5-toothed; petals 5, yellowish, on calyx tube, with short claws. Sts. 5. Ovary 1-celled, placentae 3, parietal, styles 3, stigmas fringed, ovules many. Fr. a capsule; seed coats 2, seed with aril and endosperm. — *Piriqueta* corona-like structure.

BH 73, TH 201. — GILG, Pflfam. 1925: URBAN says close relation only to *Passifloraceae* and *Malesherbiaceae.*

33. PASSIFLORACEAE (Passion Flower Family)

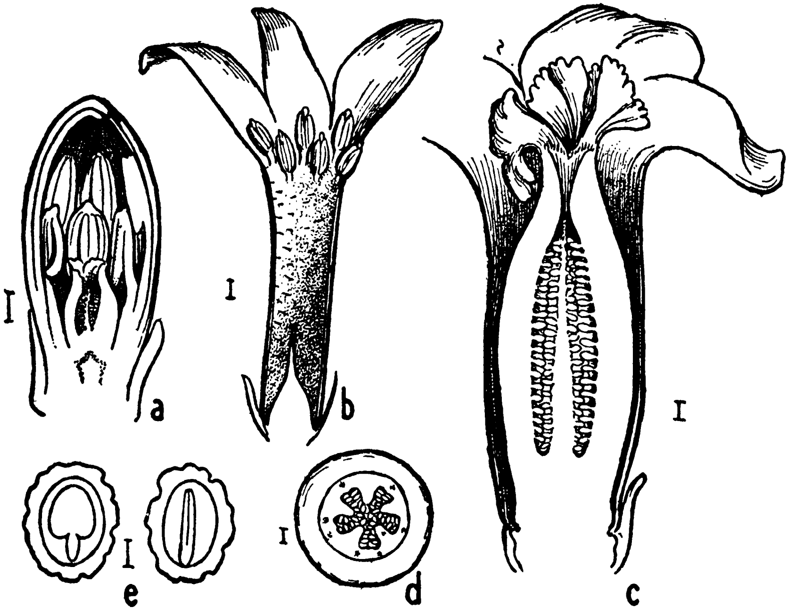
Woody plants, mostly climbing by axillary tendrils, a few herbs. Mostly in Am.; also Afr., Asia, Australia, N. Zealand; gen. 24; *Passiflora* inc. granadilla and other fruits. *Carica* inc. papaya.

Lvs. alt., usually stipulate, often with nectaries on petiole. Flowers usually large, with involucre. Sepals 4-5, often petaloid, petals somewhat fringed. Corona often brightly colored, of numerous narrow filaments; sts. mostly 4-5 opp. petals, anthers introrse. Androgynophore usual. Ovary raised, carpels 3-5, styles separate, plac. parietal. Ovules many, seed often with red aril, seed coats 2, embryo straight in endosperm. — *Adenia* dioecious. — BH 74, TH 202-205.

Malesherbia (*Malesherbiaceae* DON, 1827; TH 203). S. Am. herbs or undershrubs, densely hairy; lvs. simple, exstipulate. Floral tube 5-lobed, petals 5, small; corona denticulate. Sts. 5, adnate to gynophore. Styles 3. No aril.

Acharia Subfamily (*Achariaceae,* fam. HARMS, 1897; TH 204). So. African herbs and subshrubs; gen. 3. Monoec.; fls. in racemes. Sepals free, corolla tubular. St. fl.: sts. 3-5, epipetalous. Carp. fl.: Ovary slightly stipitate, carpels 3-5. No aril. — In lvs., fl., seed many resemblances to *Cucurbitaceae.*

Carica Subfamily (*Caricaceae* Dumortier, 1829; TH 205). Large herbs; gen. 3. *Carica,* Trop. and Subtr. Am.; *Cylicomorpha* Afr.—Terminal crown of large lvs., usually palmately lobed; latex abundant. Monoec. or dioec.; fls. in racemes. Sepals 5. Ste. fl.: corolla tube long with short lobes. Carp. fl.; corolla tube short with long lobes, styles 5. Fr. large, melonlike; seeds many, cotyledons large, flat; endosperm oily.

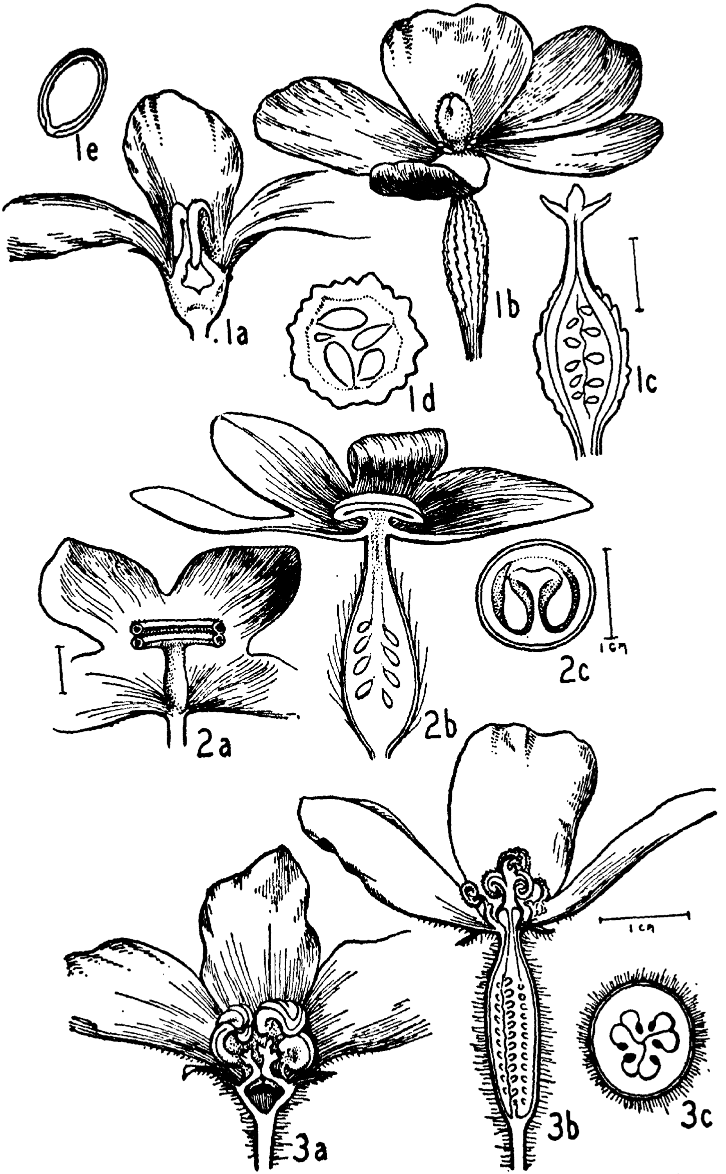


Passifloraceae.—*Carica Papaya;* a: bud, ovary open; b: ste. fl., sts. in two rows on corolla tube, rudimentary ovary; c: carp. fl., stigmas broad, nearly sessile, plac. parietal, ovules numerous; d: sec. fr., melon-like; e: seed and embryo (*cf. Cucurbita*).

Harms, Pflfam. 1925: Usteri says *Carica* is near *Euphorbiaceae* because of occasional trimery of corolla, sts. with cells sometimes separate, starch containing latex. Hallier compared testa of *Carica* with that of *Adenia.*

34. CUCURBITACEAE (Gourd Family)

Mostly climbing annuals, a few shrubs, small trees (*Dendrosicyos,* I. of Socotra), mainly Trop. and Subtrop.; gen. 100; *Cucurbita* (pumpkin and squash), *Cucumis* (muskmelon and cucumber), *Citrullus* (watermelon and citron-melon), *Luffa* (vegetable sponge).



Cucurbitaceae.—1, *Momordica charantia;* a: ste. fl., b: carp. fl., ovary inferior; c, d: secs. fr.; e: seed, double seed coat, embryo filling seed.—2, *Cyclanthera explodens;* a: ste. fl., anther circular (cut in two); b: carp. fl., c: sec. ovary.—3, *Benincasa hispida;* a: ste. fl., rudimentary pistil (*cf. Carica*); b: carp. fl., ovules many; c: sec. ovary.

Coarse, rapidly growing plants with much watery sap, usually with tendrils. Lvs. alt., mostly palmately lobed, with glandular hairs, exstipulate. Fls. often large, nearly all monoec. or dioec. Calyx tubular, 5-parted, in carp. fls., calyx tube produced beyond ovary; corolla sympetalous, rarely polypetalous. Ste. fl.; sts. 5, united at base only, in *Fevillea* and *Thladiantha;* but usually 2 connate, in 2 pairs, plus 1 free stamen, the connate ones with two-celled, the single with one-celled anther; sometimes 5 monadelphous; anther cells often twisted. Ovary inferior, ovules many or few, one in *Sechium;* 3 parietal placentae often meet in middle. Fr. large, seeds anatropous, flat, no endosperm, seed coats 2. — *Momordica* red aril; *Acanthosicyos* erect spiny shrub; *Bryonia* milky sap.

BH 75, TH 275. — COGNIAUX, Pflreich. COGNIAUX and HARMS, Pflreich, 1924 (parts). — RENDLE, 1925: *Cucurbitaceae* near *Passifloraceae* according to ROBERT BROWN, DE CANDOLLE, BENTHAM and HOOKER, HALLIER; supported by large persistent nucellus, the often extensive tapetum, the two distinct integuments, and by many other characters. — HAGERUP, 1930: Tendrils of 1-fld. spp. *Passiflora* similar to those of *Alsomitra* (*Cucurbitaceae*); in 2-fld. spp., like *Cucumis,* of foliar nature; *Cucurbitaceae* closely related to *Passifloraceae.*

35. BEGONIACEAE

Perennial succulent herbs or subshrubs; Tropics, mostly S. Am. along Andes, and to Mexico; also e. Himalayas; gen. 4, species nearly all in *Begonia.*

Hairs usually scale-like, or branching; stems swollen at nodes. Lvs. usually oblique. Monoec.; fls. cymose. Ste. fls. open first, sepals usually 2, petals 2-5; sts. many, anthers continuous with filament. Carp. fls., staminodes absent or small; ovary inferior, mostly angled or winged; styles 2-5, free, stigmas often twisted. Ovules very many on axile placentae. Fr. a capsule or berry; seeds numerous ,minute, embryo straight, endosperm little. — Tendency to union of sts. suggests *Cucurbitaceae; Hillebrandia* plac. parietal, ovary half inferior.

BH 76, TH 208. — IRMSCHER, Pflfam. 1925: FELLERER said near *Cucurbitaceae,* because of cystoliths.

36. DATISCACEAE

A few herbs, shrubs, tall trees (*Octomeles*); w. N. Am. and s. e. Asia; gen. 3.

Lvs. simple or pinnate, exstipulate. Mostly dioec. or polygamous; greenish, small. Ste. fl.: calyx-lobes 3-9, petals 8, small, or none; sts. 4-25. Carp. fl.: calyx tube adnate to 1-celled ovary, ovules many, placentae 3-8. Seeds minute, embryo straight, endosperm little.

BH 77, TH 207. — Gilg, Pflfam. 1925: Near *Begoniaceae* in fr., and especially in seed; also in palmate venation and unsymmetrical lvs.; *Datisca* and *Begonia* sts. irregular.

37. LOASACEAE

Herbs and shrubs, sometimes climbing; Great Plains, N. A., to Chile and Argentina; *Kissenia* in E. Afr. and W. As.; gen. 12.

Lvs. usually with hooked, sometimes stinging hairs; exstipulate. — Fls. usually perigynous, sepals 4-5, petals 4-5, flat or cucullate. Sts. many, or 4-5, outer ones often petaloid. Ovary usually inferior, 1-celled, with 3 parietal placentae; carpels straight in bud, often spirally twisted later. Fr. a capsule, with many small seeds. Seed coat 1, embryo straight, with or without endosperm.

BH 73, TH 206. — Gilg, Pflam. 1925: Position of family uncertain; seeds of *Loasaceae* and *Begoniaceae* have many resemblances; sts. vary greatly. — Schürhoff, 1926: Haploid development as in typical *Sympetalae;* integ. 1, tapetum, tenuinucellate, all nucellus resorbed by embryo-sac, endosperm cellular, micropyle and chalazal haustoria; perhaps near *Symplocaceae.*

SALICALES

Chromosomes:
Salicaceae — Populus, Salix 19.

38. SALICACEAE (Willow Family)

Trees and shrubs in N. Temp. and Arctic Regions, a few in S. Am. and S. Afr., absent from Australasia; gen. 2; *Populus* wind-pollinated, *Salix* mostly insect pollinated.

Bark bitter, wood soft, vessel perforations porous. Lvs. alt., stipulate. Dioec., both sexes in catkins; in *Salix,* bract below each fl., in *Populus,* cupule. Sts. 2-many, separate or connate below. Ovary 1-celled, carpels 2, stigmas 2-4. Ovules many, parietal-laminal, mostly basal. Fr. a capsule, seed coats 2; seed anatropous, with basal tuft of silky hairs; endosperm none.

BH 160, TH 56.—PENHALLOW, 1905: Geographical, geological, anatomical evidence all in one direction, showing that *Populus* is the primitive genus through which to seek connection with ancestral forms.—HALLIER, 1913: *Populus* probably related to *Idesia* (*Flacourtiaceae*).—HOLDEN, 1912: *Salix* has nectar glands; *Salix* and *Populus* are porogamous, like higher dicotyledons, while *Casuarinaceae, Juglandaceae, Fagaceae* are chalazogamous; step from gymnospermy to chalazogamy is short, to porogamy considerable; low position of family not justified.—FISHER, 1928: Anatomy of vascular bundles suggests that nectaries of *Salix* and cupule of *Populus* represent a reduced perianth; *Populus* is more primitive than *Salix,* but its wind-pollination is an acquired character. Catkin is an advanced type of infl., with lateral branches lost; family is derived from primitive group, but much specialized.

PAPAVERALES

Mostly herbaceous, perianth 2-4 parted, plac. parietal, sometimes secondary walls. Petals probably modified bracts.

Chromosomes:
Capparidaceae — *Capparis* 9, 10; *Polanisia* 10; *Cleome* 10, 11.
Cruciferae — Varies from 5 to 15.
Moringaceae — *Moringa* 7.
Papaveraceae — *Chelidonium, Glaucium, Eschscholtzia* 6; *Argemone* 7; *Papaver* 6, 7, 11; *Bocconca* 10, *Adlumia, Corydalis, Dicentra* 10.
Resedaceae — *Reseda* 6, 7, 10.

39. PAPAVERACEAE (Poppy Family)

Herbs, rarely shrubs (*Dendromecon*) or small trees (*Bocconea*), mostly in N. Temp. Zone; gen. 30.

Lvs. alt. Sepals 2, rarely 3, falling early. Petals 4-6. Sts. many, 6 or 4. Carpels 2-many. Parietal placentae growing into ovary, rarely meeting to make a many-celled ovary; ovules laminal. Fr. a capsule. Seed sometimes with aril. Embryo small, curved in endosperm.

Papaveroideae. Latex white or colored. Fls. regular, often large. Petals often crumpled in bud, usually bright colored. No nectar glands, fls. visited by insects for pollen. Style short or none, stigmas sometimes form large, lobed structure. — In *Platystemon,* fls. 3-parted, carpels separate in fruit; *Bocconia* apetalous, seed solitary.

Hypecoideae. Petals without spur, sts. 4. — In *Pteridophyllum* sts. 2.

Fumarioideae (*Fumariaceae* of DC., of GRAY, of HUTCHINSON) Glabrous herbs without latex. Fls. zygomorphic or bilaterally symmetrical, with nectar glands. Sepals 2, petals 2+2, often connate at tip; sts. 3+3, in two bundles; carpels 2, united, style slender. Endosperm starchy.

BH 10, TH 104. — FEDDE, Pflreich. 1909 (part). — FRIEDEL, 1933: *Oceanopapaver,* link toward *Capparidaceae* and *Cistaceae.* — DICKSON, 1934: Floral anatomy of *Glaucium* is comparable to that of *Cruciferae.*

40. RESEDACEAE (Mignonette Family)

Herbs, rarely subshrubs; mainly Medit. or India, some in Africa and Calif.; gen. 6.

Lvs. alt., stipules glandular. Fls. zygomorphic, with short androgynophore and 1-sided disk with nectar-secreting surface. Sepals and petals 4-8 each, petals often laciniate. Sts. 3-40. Carpels curved, with parietal placentae, ovary usually open at top. Seed filled by curved embryo, no endosperm.

BH 13, TH 108. — HENNIG, 1930: Many peculiarities: dorsiventrality; porogamy; but embryo develops like *Cruciferae; Caylusea* and *Astrocarpus,* carpels separate. *Caylusea* 2-3 basal placentae; internode between calyx and

Koeberlinia (*Koeberliniaceae* ENGLER, 1895; DIELS sub *Capparidaceae*). Shrubs, Texas and Mexico. Resin tubes; stellate hairs; fr. a berry.

Tovarioideae; Trop. Am. herbs; gen. 1 (*Tovariaceae* PAX, 1891; EICHLER sub *Papaveraceae*). Sepals, petals, sts. each 8; ovary 6-8 celled; plac. axile; ovules campylotropous, in endosperm. — PAX & HOFFMAN, Pflfam. 1936: *Tovaria* between *Papaveraceae* and *Capparidaceae;* plac. distinct.

42. MORINGACEAE

Old world trees; n. e. Afr. and India; gen. 1.

Lvs. alt., 2-3 pinnate, stipules fall early. Fls. perigynous, zygomorphic. Calyx 5-parted, petals 5, unequal. Sts. 8-10, separate or united at base, alt. ones shorter or reduced to staminodia. Disk lining calyx tube. Ovary raised on gynophore, 1-celled, placentae 3, style 1, tubular, (*cf. Viola*), open at top; ovules many. Fr. a capsule; seed winged, embryo straight, cotyledons thick, endosperm none. — Differ from *Capparidaceae* in 5-parted fls., 3 carpels, capsule loculicidal. *Moringa* sometimes three cotyledons.— Near *Capparidaceae;* characters also suggest *Leguminosae* and *Bignoniaceae.* — BH 55, TH 109. — PAX, Pflfam. 1936.

43. CRUCIFERAE (Mustard Family)

Mostly herbs, many annuals and biennials; cosmopolitan, mostly N. Temp. Zone, some Arctic, many Medit.; gen. 200; *Brassica* (cabbage, etc.), *Raphanus* (radish); very natural family.

Lvs. vary even in same genus, exstipulate. Fruits mostly in racemes, corymbose in flowering stage. Sepals 4, in two pairs; petals 4, often long-clawed, rarely none, glands opp. sepals. Sts. mostly 2 short, 4 long (tetradynamous). Carpels 2, united; 2- rarely 1-celled; parietal placentae at edges of septum. Fr. usually a two-celled pod, long or short; embryo with cotyledons variously curved or folded, character used to separate genera. No endosperm. — *Nasturtium* sometimes four carpels; *Megacarpaea* 8-15 stamens; *Iberis* fl. zygomorphic; *Lepidium* and others sometimes apetalous.

BH 11, TH 105. — EAMES and WILSON, 1928: In *Capparidaceae, Fumariaceae* and *Cruciferae,* there are two kinds of carpels, valve or sterile, and solid or fertile carpels. The ovules, though attached to the solid carpels are situated in loculi of the sterile carpels. — ARBER, 1931: Prefers bicarpellary to quadricarpellary theory. — SPRATT, 1932: Posterior-anterior position of stigmas as in *Umbelliferae* and many *Sympetalae* implies 2 carpels, not 4; ovules on midrib of carpels suggest changes from margin to midrib. Family represents an ascending series from *Ranales;* lateral sepals come first; ovules have moved from marginal to laminal position also in *Papaveraceae.* — SCHULZ, Pflfam. 1936.

SARRACENIALES

Lf. blades insect-catching. Fls. solitary or few on long stem.

Chromosomes:
Droseraceae — *Drosophyllum* 6, *Drosera* 10, *Dionaea* 15, 16.

44. NEPENTHACEAE

Insectivorous, slightly woody plants; East Indies, esp. Borneo, also in Madagascar and N. Australia; gen. 1.

Lvs. alt., of three parts: broad base; stalk-like, often climbing part; pitcher with lid. Dioec., fls. small. Perianth 2 + 2 parts. Sts. 4-24, filaments united. Ovary usually 4-celled, ovules many in each cell, stigmas sessile. Fr. a capsule, seed winged, with endosperm.

BH 136, TH 111. — MACFARLANE, Pflreich. 1908: BRONGNIART grouped *Nepenthaceae* with *Cytinaceae:* LINK near *Aristolochiaceae;* important resemblances are: sts. united, anthers extrorse; radiating, sessile stigmas; many celled ovary and many seeds. LINDLEY, EICHLER, and ENGLER suggested affinities with *Sarraceniaceae* through *Heliamphora;* MACFARLANE believed *Nepenthes* might be in same family. — KUHL, 1933: Pollen and ovule development of *Nepenthes* indicate that relationship to *Sarracenia* is doubtful. — HARMS, Pflfam. 1936: *Sarraceniaceae* and *Nepenthaceae* perhaps from *Ranales* line; *Droseraceae* doubtfully related. — SKOTTSBERG, 1940: *Nepenthales* separate order.

45. SARRACENIACEAE (Pitcher Plant Family)

American bog plants, insectivorous; gen. 3; *Sarracenia* in e. N. Am.; *Darlingtonia* in Calif.; *Heliamphora* on Mt. Roraima, British Guiana.

Lvs. radical, pitchers brightly colored, partly filled with watery fluid. Central scape with 1 or a few large fls., spirocyclic. Sepals 8-5, petals 5, sts. many. Ovary 3-5 celled; ovules many, anatropous, on axile placentae. Seed coat 1, embryo straight, in endosperm. — *Sarracenia* style large, umbrella-like, spread under sts. in the inverted fl.; 5 stigmas are near apex of lobes.

BH 9, TH 110. — MACFARLANE, Pflreich. 1908: Very near *Nepenthaceae;* fl. also like *Drosera.* WARMING suggested near *Cistaceae,* perhaps between that and *Papaveraceae.* — UPHOF, Pflfam. 1936: BH between *Nymphaeaceae* and *Papaveraceae,* ENGLER says suggestive of *Nuphar.*

46. DROSERACEAE (Sundew Family)

Insectivorous, glandular, small bog plants; cosmopolitan; gen. 6.

Often stemless, lvs. in rosette. Sepals 4-5, somewhat connate, petals 5. Sts. in 1 or more whorls of 5. Ovary 1-celled, carpels 2-5, placentae parietal or basal. Fr. a capsule; seeds many, anatropous; embryo small in endosperm. — *Aldrovanda* floating water-plant; *Drosophyllum* many sts.

BH 61, TH 112. — DIELS, Pflfam. 1936: JUSSIEU placed *Drosera* under *Resedaceae;* in Prodromus *Droseraceae* are next to *Violaceae;* AGARD pointed out resemblances to *Saxifraga tridactylites* in red color, glandular hairs, bulbils, tendrils, similarity of perianth, sts., ovules.

ARISTOLOCHIALES

Fls. solitary, usually 3-parted, sts. 6 or more, connate, anthers extrorse, ovary inferior.

Chromosomes:
Aristolochiaceae — *Aristolochia* 7, *Asarum* 12.

47. ARISTOLOCHIACEAE

Twining shrubs or low herbs in warm and temp. regions; gen. 6.

Vessel perforations simple. Lvs. usually heart-shaped, entire. Fls. perfect, perianth single, double in *Saruma;* petals represented by scales in *Asarum*. Sts. 6-many, more or less united with the columnar style, anthers extrorse. Ovary inferior, 4-6 celled, plac. axile, ovules many. Seeds more or less flat, anatropous, with large fleshy raphe. Endosperm abundant, embryo small.—*Asarum* has aril; *Hexastylis* superior ovary. — *Aristolochiaceae* have several characters in common with *Cucurbitaceae*.

BH 138, TH 74. — SCHMIDT, Pflfam. 1935: Reviews BALDACCI, who believed *Aristolochiaceae* to be near *Menispermaceae;* WAGNER near *Annonaceae;* WETTSTEIN highly specialized position in *Ranales;* MEZ near *Myristicaceae;* SCHMIDT maintains ENGLER's position.

48. RAFFLESIACEAE

Parasitic herbs, with vegetative parts reduced to mycelium-like tissue in host plant, widely distributed chiefly in Tropics; gen. 8; *Rafflesia Arnoldii* in Sumatra, world's largest flower.

Fls. unisexual, perianth 4-10 parts, preceded by scale leaves, anthers on fleshy column. Ovary inferior or half-inferior, 1-celled. Ovules numerous on parietal placentae; seeds small, embryo minute, endosperm present.

BH 137, TH 75. — SOLMS-LAUBACH, Pflreich. 1901: Central carpel column like *Aristolochiaceae*. — HARMS, Pflfam. 1935: Already in 1821 ROBERT BROWN believed *Rafflesia* near *Asarum* and *Passiflora;* HUNZIGER says near *Cucurbitaceae*.

49. HYDNORACEAE

Root parasites in Africa, 1 sp. in Argentina; gen. 2.

Rhizome growing from root, generally on *Acacia* or *Euphorbia*. Fls. perfect, with whorl of 3-4 fleshy perianth parts, connate below. *Hydnora* many sts. in tube, *Prosopanche* 3 sts. united. Ovary inferior, 1-celled, stigma sessile, ovules many. Embryo small, with endosperm and perisperm.

TH 76. — SOLMS-LAUBACH, Pflreich. 1901: Usually tribe of *Rafflesiaceae*, but sts., ovary and seed differ; perisperm has horny partitions. — HARMS, Pflfam. 1935: Probably near *Rafflesiaceae*. — MATUDA, 1947: The peculiar genus *Mitrastemon* should form family *Mitrastemonaceae*, as suggested by MAKINO in 1928.

TAMARICALES

Dry climate plants, lvs. usually small, exstipulate, plac. parietal.

Chromosomes:
Elatinaceae — *Bergia* 6.
Frankeniaceae — *Frankenia* 10.
Fouquieraceae — *Fouquiera* 8.
Tamaricaceae — *Tamarix, Myricaria* 12.

50. TAMARICACEAE

Old World shrubs; seashore and desert plants of Medit. and C. Asia; gen. 4.

Lvs. usually small, narrow, exstipulate. Fls. small in slender racemes. Sepals 4-5, free, petals 4-5, free. Sts. 5-10, sometimes connate at base. Ovary 1-celled, plac. basal or parietal, styles 3-4, ovules many. Fr. a capsule, seeds with tuft of hairs at apex, embryo straight. — *Reaumuria* and *Hololachne,* fls. solitary, seed with endosperm.

BH 24, TH 191. — NIEDENZU, Pflfam. 1925: Possibly near *Salicaceae* on account of ovary, placentation, ovules, fruit and seed; *Tamarix* 3-4 carpels, *Salix* 2.

51. FRANKENIACEAE

Perennials and undershrubs, a few annuals, widely distributed, mostly along subtropical coasts and in dry climates:. Calif., S. Am., Medit., Australia; gen. 5.

Stems jointed at nodes; lvs. opp., small, entire, exstipulate. Fls. in terminal or axillary cymes. Calyx tubular, usually 5-6 parted, petals same number, each with claw and ligular scale; blade spreading. Sts. 3 + 3, in *Hypericopsis* many; filaments united at base. Ovary usually 3 carpels, 1 cell, style long, 3 stigmas, plac. parietal, ovules several, sometimes a few or 1, basal. Fr. a capsule inside persistent angular calyx tube. Embryo straight, in endosperm, seed coats 2.

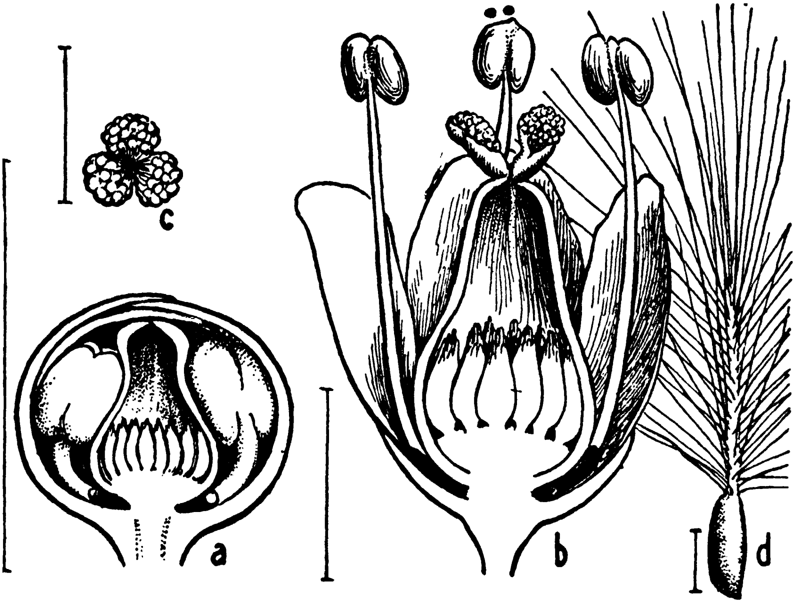
BH 21, TH 190. — SURGIS, 1920: With key to the five genera. — NIEDENZU, Pflfam. 1925. — GUNDERSEN, 1927: Many resemblances between *Frankeniaceae* and *Caryophyllaceae.*

52. ELATINACEAE

Small annual, glabrous, aquatic and marsh herbs, often in stagnant pools; cosmopolitan; gen. 2.

Lvs. opp. or whorled, simple; with membranous stipules, (*cf. Caryophyllaceae*). Fls. small; axillary, single or cymose. Sepals 3-5, petals 3-5, persistent, sts. as many or twice as many. Ovary 3-5 celled, plac. axile, styles 3-5, ovules many. Fr. a capsule, embryo often curved, endosperm none. — Many resemblances to *Caryophyllaceae*.

BH 25, TH 189. — NIEDENZU, Pflfam. 1925: Nearest to *Tamaricaceae* and *Frankeniaceae;* DC sub *Caryophyllaceae.*



Tamaricaceae. — *Tamarix pentandra;* a: bud, half mm., plac. basal, no styles; b: fl., three mm.; c: styles, three spatulate stigmas converging, with pollen grains; d: seed, hairy tuft at top (in *Salix,* hairs from base of seed).

53. FOUQUIERACEAE

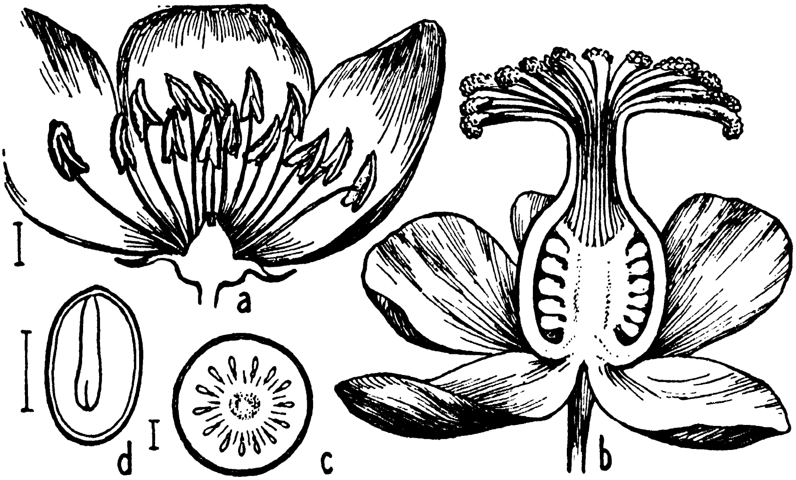
American shrubs or small trees, wand-like, spiny; Colorado Desert to Texas and Mexico; gen. 1.

Lvs. small, fleshy. Fls. showy in panicles. Sepals 5, unequal, much imbricate. Corolla tubular, 5 recurved lobes, pointed. Sts. 10-15, disk small. Ovary 1-celled, 3 parietal placentae, each with about 6 ovules. Fr. a capsule; seeds with long hairs, or winged; embryo straight, endosperm oily. — TH 192.

THEALES

Sepals imbricate, petals imbricate or contorted, sts. many, free or connate, plac. axile, embryo usually fills seed.

Chromosomes:
Dilleniaceae — *Hibbertia* 9, *Wormia* 13.
Guttiferae — *Hypericum* 8, 9, 10, 12; $2n = 19$ $(9 + 10)$.
Theaceae — *Thea* 15.



Actinidiaceae. — *Actinidia arguta;* a: ste. fl., sepals small, petals large, sts. many, anthers versatile, ovary rudimentary; b: carp. fl., carpels many, styles radiating, plac. axile; c: sec. fr.; d: seed, embryo straight, large, in endosperm.

54. DILLENIACEAE

Trees, shrubs and lianas; *Acrotrema* and some *Hibbertia* herbaceous; Tropics, especially Australia; *Hibbertia* nearly all in Australia; gen. 12.

Lvs. evergreen, stipules adnate to petiole or none. Fls. often large. Sepals 5 or many, petals 5. Sts. usually many, staminodia frequent. Carpels 1-many, free or partly united, styles free, ovules 1-many, plac. axile. Embryo small, straight, aril conspicuous, endosperm abundant. — Many resemblances to *Ranunculaceae,* esp. to *Paeonia.*

BH 2, TH 180. — GILG and WERDERMANN, Pflfam. 1925: Near *Theaceae,* but habit entirely different; many sts. probably a primitive character.

55. ACTINIDIACEAE

Trees, shrubs (*Saurauia*) and climbers (*Actinidia*); Trop. Am., E. Asia; gen. 3.

Lvs. simple, exstipulate, hairs often stellate. Sepals 5, petals 5. Sts. 1-many, free or adnate to petals. Ovary of 5-many carpels. Fr. a berry or capsule. Seeds anatropous, 1-many in each carpel, embryo straight, seed coat 1, endosperm abundant.

BH, TH sub *Dilleniaceae.* — GILG and WERDERMANN, Pflfam. 1925: Seed coat 1, *Dilleniaceae* proper always 2 seed coats; HALLIER placed *Actinidia, Saurauia* and *Clematoclethra* with *Clethraceae.*

(*Saurauiaceae,* fam. HUTCHINSON, 1926, DIELS sub *Actinidiaceae.* Petals usually shortly connate at base, anthers opening by apical pore or short slit.)

56. EUCRYPHIACEAE

Small trees; Chile, Australia and Tasmania; gen. 1.

Lvs. opp., simple or pinnate, stipulate. Fls. axillary, large, white, rose-like. Sepals 4, rigid, cohering at apex; petals 5. Sts. many, in several series on thin disk; anthers small, orbicular. Ovary 5-12 or more celled; styles separate. Plac. axile, ovules many in each cell. Fr. a capsule, seeds winged, seed coats 2, endosperm abundant.

TH 181. — GILG, Pflfam. 1925: Near *Theaceae,* but separate family.

57. OCHNACEAE

Trees and shrubs, never climbing; widely distributed in Tropics, esp. Brazil; gen. 20.

Lvs. alt., simple, rarely pinnate, veins conspicuous, stipulate. Fls. usually yellow. Sepals 4-5, rarely 10, free, petals 4-10. Sts. few to many, filaments persistent, anthers with terminal pore. Staminodes sometimes present, subulate or petaloid, sometimes connate. Ovary 1-10 celled, sometimes deeply lobed, with gynobasic style; ovules 1-many, parietal or axile. Fr. carpels often separate on enlarged torus; embryo large, seeds 1-many, with or without endosperm; no aril. — Great diversity of forms; *Lophira, Luxemburgia, Wallacea* as families of VAN TIEGHEM.

BH 41, TH 182.—VAN TIEGHEM, 1904: *Wallacéacées,* with plac. parietal. — GILG, Pflfam. 1925: *Ochnaceae* fls. in part spirocyclic.

Strasburgeria (genus BAILLON 1876, BH and TH sub *Ochnaceae;* fam. of VAN TIEGHEM, 1903, and of DIELS, 1936). Shrub, New Caledonia. Lvs. obovate, stipulate. Fls. single, axillary, spirocyclic. Sepals 8-12, unequal petals 5; sts. 10, obdiplostemous; carpels 5, each with 1 ovule; fr. woody. — ENGLER, Pflfam. 1925: Anthers suggest *Brexia* (*Saxifragaceae*), but probably nearest *Ochnaceae.*

58. DIPTEROCARPACEAE

Trees, a few shrubs; India and Malayan Region; a few in Afr.; gen. 15; many Philippine forest trees; *Shorea, Hopea* and others, large timber trees; *Dryobalanops* (Borneo camphor).

Wood contains resin. Lvs. alt., entire, with stellate or scaly hairs, stipulate. Fls. fragrant, in axillary panicles. Calyx tube long or short, free or adnate to ovary, lobes 5, some much enlarged and wing-like in fr. Petals 5, twisted, often hairy. Sts. usually many, sometimes 5, connective greatly prolonged. Ovary 3-celled, ovules 2 in each cell. Fr. indehiscent, mostly 1-seeded. Cotyledons twisted, seed coats 2, endosperm none.

BH 29, TH 188.—Gilg, Pflfam. 1925.

59. ANCISTROCLADACEAE

Old World lianas; India to Indo-China, also w. Trop. Afr.; gen. 1.

Branches with hooks, lvs. alt., stipules small. Fls. small, in panicles. Calyx and corolla 5-parted, petals slightly connate. Sts. 5 or 10. Ovary inferior, 1-celled, ovule 1, basal; style short, stigma 3-lobed. Fr. a nut, surrounded by wing-like calyx lobes. Seed coats 2, cotyledons folded, endosperm present.

TH 209.—Gilg, fam. 1895; Pflfam. 1925: Resembles *Dipterocarpaceae,* but differs in axile plac., half-turned basal ovule, peculiar endosperm, sepals imbricate in bud.

60. MEDUSAGYNACEAE

Medusagyna, shrub; Seychelles Is.; sp. 1.

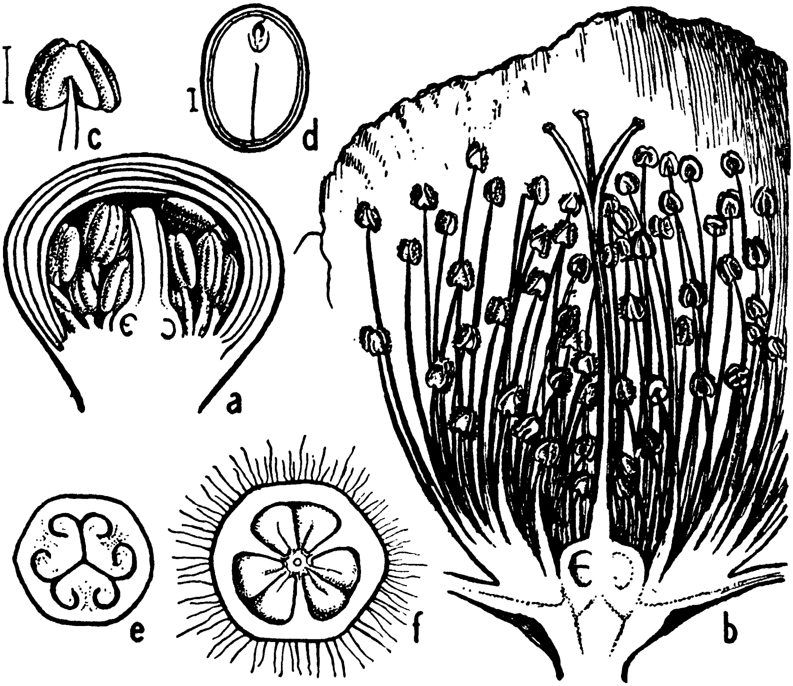
Lvs. opp., exstipulate. Fls. in terminal panicles, red. Sepals 5, deciduous, petals 5, free. Sts. very numerous, filaments free, slender. Ovary of 20-25 cells, carpels nearly free; styles stout, forming a ring, stigmas capitate. Ovules 2 in each cell. Fr. a capsule, seeds winged.

Hemsley, 1905, fam.—Engler and Melchior, Pflfam. 1925: Resembles *Eucryphia* in anthers, numerous sts., numerous carpels, and free styles.

61. THEACEAE (Tea Family)

Trees and shrubs; Tropics and warm temperate regions, esp. e. Asia; gen. 15.

Lvs. alt., mostly evergreen, mostly exstipulate. Fls. often large, regular, usually solitary, often spirocyclic. Sepals and petals mostly 5, often somewhat sympetalous. Sts. mostly many, or in 5 bundles, attached to base of petals; anthers usually opening lengthwise, sometimes by terminal pore. Ovary 3-5 celled, ovules 2-more in each cell; no aril. Embryo folded or twisted, endosperm little. Seed coats 2 or 1.



Theaceae.—*Thea sinensis;* a: bud; b: fl., sts. numerous, filaments slender, connate below, with petals, inner sts. free, styles three, filiform, ovules few; c: anther, large connective; d: seed, seed coats two, no endosperm; e: ovary in bud with plac. parietal; f: adult with plac. axile, axis becomes woody (*cf. Ericaceae*).

BH 28, TH 186.—Melchior, Pflfam. 1925: Varied floral structure shows resemblance to families far from each other; *Bonnetia, Asteropeia, Tetramerista* and *Pelliciera* groups might be assigned family rank; but for practical reasons are kept within *Theaceae; Asteropeia* anatomy near Homalium (*Flacourtiaceae*).—Melchior, 1929.

62. QUIINACEAE

American trees and shrubs, a few climbers; Trop. Am.; gen. 2.

Lvs. opp. or whorled, lateral veins numerous; stipules paired, intrapetiolar. Sepals 4-5, unequal, petals 4-8. Sts. 15-30 or more, usually free. Ovary 2-many celled, styles 2-3, with disk-like stigmas. Fr. a few-seeded berry. Seeds pubescent, endosperm none.

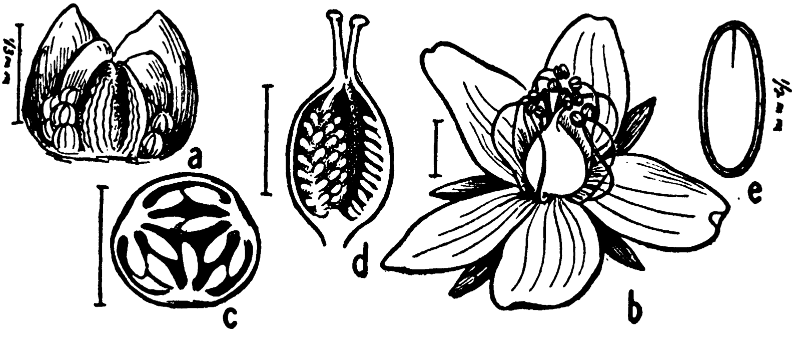
TH 185. — Engler, 1888, fam.; and Pflfam. 1925: No oil canals; seeds with short dense hairs; no expanded receptacle; probably near *Ochnaceae* and *Theaceae*.

63. CARYOCARACEAE

Trees and shrubs; Trop. Am.; gen. 2.

Lvs. palmately 3-5 foliolate, stipulate. Calyx 5-6 lobed, petals 5-6, free or cohering at tips. Sts. many, in bundles or shortly connate at base; filaments very long, anthers small. Ovary 4-20 celled, as many long styles; ovule 1 in each cell. Fr. breaking up into one-seeded parts; seeds kidney-shaped, cotyledons small, endosperm little.

TH 183. — *Rhizoboleae* DC. — Pilger, Pflfam. 1925: Two peculiar genera, near *Theaceae*.



Guttiferae. — *Hypericum majus;* a: bud, half mm., no style; b: fl., sts. ten, filaments slender, styles three, stigmas capitate; c, d: ovary, plac. parietal; e: seed, no endosperm.

64. MARCGRAVIACEAE

Climbing shrubs, mostly epiphytic, a few trees; Trop. Am.; gen. 5; *Marcgravia, Norantea.*

Lvs. simple, alt. often two kinds: on sterile branches, small, rounded, in two ranks; on flowering branches, longer, with distinct petioles; spirally arranged; exstipulate. Fls. of two kinds: fertile fls. 4-5 parted. Sts. 4-many, free or connate. Ovary mostly 5-celled, sometimes 2 to many-celled. Plac. at first parietal, then placentae fuse in middle. In sterile fls. bracts are modified into pitcher-like bodies, often adnate to pedicel. Fr. a thick and globose capsule, seeds many, small; no aril or endosperm.

TH 184. — GILG and WERDERMANN, Pflfam. 1925: Very natural family, anatomically and morphologically, also by peculiar habit; near *Theaceae.*

65. GUTTIFERAE (St. John's Wort Family)

Trees, shrubs, some lianas, few herbs; Tropics, some Temp.; gen. 45; *Garcinia* (mangosteen), *Mammea* (mammee apple), tropical fruits.

Usually contain resin or oil. Lvs. mostly sessile, opp. or whorled, dotted with pellucid glands, exstipulate. Fls. often large. Sepal and petal numbers vary, often 5. Sts. many to 4, often in bundles, partly sterile. Carpels 3-5, also 1-many, ovules many, usually axile, sometimes parietal. Aril frequent, seed coats 2, endosperm none.

Hypericoideae (*Hypericaceae* of BH, of HUTCHINSON). Mostly herbaceous; branches not jointed; lvs. less coriaceous; fls. always perfect, styles filiform.

BH 27, TH 187. — ENGLER Pflfam. 1925: Fl. structure very near *Theaceae,* also near *Dipterocarpaceae.* — VESTAL, 1937: Anatomy of *Guttiferae* indicates nearest families are *Theaceae* and *Hypericaceae.*

EBENALES

Chromosomes:
Ebenaceae — *Diospyros* 15.
Sapotaceae — *Palaquium* 12, *Achras* 13.
Styracaceae — *Styrax* 8, *Halesia* 12, *Pterostyrax* 12.

66. SYMPLOCACEAE

Trees and shrubs; s. e. Asia, Australia, Trop. Am., s. e. U.S.; not in Africa; gen. 1.

Lvs. alt., exstipulate. Calyx lobes usually 5, corolla slightly connate, lobes 5 or 10. Sts. epipetalous, usually in series, sometimes in bundles. Ovary inferior or half-inferior, 2-5 celled, ovules 1-2 in each cell, pendulous. Fr. usually drupe-like; seed coat 1; endosperm present. — Many characters in common with *Theaceae.*

TH 242. — Brand, Pflreich. 1907.

67. STYRACACEAE

Shrubs and small trees; s. e. U.S., C. and S. Am., e. Asia and Medit., gen. 6.

Hairs often stellate or scaly. Lvs. alt., simple, entire. Calyx 4-5 lobed, more or less adnate to ovary, corolla 4-8 lobed, lobes almost separate. Sts. mostly twice as many as lobes of corolla, sometimes same number, epipetalous. Ovary superior, rarely half-inferior, 1-celled at top, 3-5 celled at bottom. Ovule 1, rarely several, in each cell; style 3-5. Fr. mostly a drupe, calyx persistent; seed coat 1; endosperm abundant.

BH 103, TH 241. — Perkins, Pflreich. 1907: Near *Symplocaceae.* — Copeland, 1938: Each placenta about eight ovules, apotropous, bitegmous, tenuinucellate, with obturators; only 1 ovule matures; family in *Ebenales;* ancestral line near *Theaceae.* — Chevalier, 19...: *Hua* and *Aprostyrax* with separate petals, 4-celled anthers, 1-celled ovary should form family *Huacaceae,* more primitive than *Styracaceae.*

68. LISSOCARPACEAE

Lissocarpa, American small tree; n. Brazil; sp. 1.

Lvs. alt., entire, exstipulate. Fls. cymose. Calyx tube shortly adnate to base of ovary, lobes 4. Corolla tube 4-lobed, lobes contorted. Sts. 8, from near base of corolla, filaments connate. Ovary nearly superior, 4-celled, ovules 2 in each cell, pendulous. Fr. indehiscent, 1-2 seeded; seed 3-ribbed, embryo straight, endosperm abundant.

69. EBENACEAE (Ebony Family)

Trees and shrubs; Tropics and Subtropics, chiefly Old World; gen. 5; *Diospyros Ebenum* (ebony), *D. Kaki* (Japanese persimmon), *D. virginiana* (American p.).

Wood hard, dark or black. Lvs. alt., simple, entire, leathery, exstipulate. Polygamous or dioec. Calyx 3-6 lobed, persistent, often accrescent. Ste. fls. with rudimentary ovary; sts. often in pairs, mostly double number of corolla lobes; filaments short, with projecting connective; anthers introrse. Carp. fls. usually solitary; ovary 2-16 celled; ovules 1 or 2 in each cell, anatropous, suspended; style often divided. Fr. more or less succulent; seed coats 2, cotyledons flat, in hard endosperm. — BH 102, TH 240.

70. SAPOTACEAE (Sapodilla Family)

Mostly trees, some shrubs; widely distributed in Tropics; gen. 40, inc. *Achras* (sapodilla), source of chicle; *Palaquium* (gutta-percha).

Latex present; lvs. alt., simple, entire, leathery, exstipulate. Fls. usually small, calyx 4-8 lobed, sometimes sepals free. Petals usually in single whorl, more or less united. Sts. epipetalous, usually in 2 or 3 whorls, outer whorl often sterile. Carpels as many or twice as many as number of sts. in a whorl; ovary superior, several-celled, ovules anatropous, 1 in each cell; style 1, stigma small. Fr. a hard berry; embryo large with broad cotyledons, seed coat 1; usually little endosperm. — BH 101, TH 239.

Sarcospermataceae LAM, fam. 1925; LAM and VAROSSIEAU, 1938: Near *Sideroxylon*, but with glandular pits, subopposite lvs., branched infl., basifixed anthers.

71. HOPLESTIGMATACEAE

Large trees; Trop. W. Afr., gen. 1.

Lvs. large. Fls. many in long-stemmed clusters, secund. Calyx at first globular, firmly enclosing fl. bud, later breaking into 2-4 parts. Lower third of corolla cylindrical, with about a dozen lobes in 3-4 irregular whorls. Sts. about twice as many as petals, in irregular whorls on corolla tube. Ovary of 2 carpels, 1-celled, with 2 thick parietal placentae, each with 2 pendulous ovules. Fr. a drupe; seed coat thin, embryo large, endosperm little.

Hoplestigma PIERRE, 1899, in *Flacourtiaceae;* DIELS after *Sapotaceae.*

ERICALES

Chromosomes:

Clethraceae — Clethra 8.

Diapensiaceae — Diapensia, Galax, Pyxidanthera, Shortia 6. — BALDWIN, 1939: *Galax* 2n:24.

Empetraceae — Corema, Empetrum 13.

Ericaceae — Calluna 8; *Pernettya* 11; *Kalmia* 11, 12; *Erica, Phyllodoce, Pieris* 12; *Gaylussacia, Vaccinium* 12; *Arbutus, Arctostaphylos, Ledum, Rhododendron* 13; — HAGERUP, 1938: *Pyrola* 23; *Gaultheria* 48. — COPELAND, 1937: *Pleuricospora* 26; COPELAND ined. *Chimaphila* 13.

72. CLETHRACEAE

Tall shrubs or small trees; Atlantic U. S. to Brazil, Madeira, also e. Asia; gen. 1.

Lvs. alt., serrate. Fls. white, in racemes. Calyx 5-parted, persistent; petals separate. Sts. 10, anthers sagittate, in fl. inverted, opening by terminal pores. Ovary superior, 3-celled, style 1, stigmas 3; ovules many. Fr. a loculicidal capsule; seeds many, embryo cylindric, endosperm fleshy. — TH 230.

73. ERICACEAE (Heath Family)

H. F. COPELAND, 1948: Shrubs and subshrubs, a few small trees; mostly temperate and cold regions, on mts. in Tropics; gen. 100.

Lvs. mostly evergreen, fls. perfect, regular or slightly irregular. Calyx 5-4 parted, persistent. Corolla sympetalous (polypetalous in *Bejaria, Leiophyllum, Monotropa, Ledum* and others), 5-4 lobed. Sts. normally twice as many as petals, sometimes only as many, inserted at base of hypogynous disk, not epipetalous; anthers often appendaged, mostly opening by terminal pores, sometimes longitudinally. Pollen grains in tetrads, rarely solitary. Ovary 5-4 celled, or falsely 10-celled; ovules many; style 1, stigma 1. Fr. a capsule, rarely a berry or drupe. Embryo straight, or reduced, without distinct parts, in endosperm. — TH 231, 233.

Rhododendroideae (*Rhodoraceae* of WARMING, MÖBIUS). Anthers, without appendage, capsule septicidal. *Elliottia, Rhododendron, Ledum, Kalmia.*

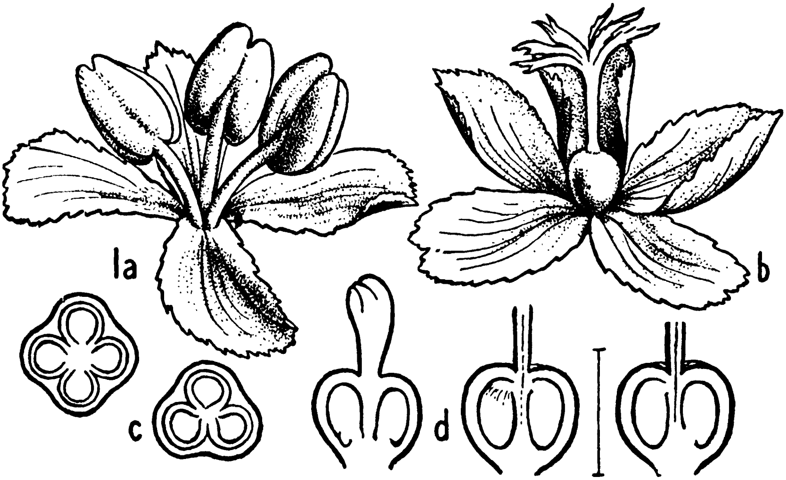
Arbutoideae, fr. usually a loculicidal capsule, or berry, or drupe. ***Arbutus, Arctostaphylos, Andromeda.***

Pyroleae, capsule septicidal, petals separate.

Monotropoideae (*Monotropaceae* of BH, of Hutch.) Saprophytes; stem fleshy; scales instead of leaves; pollen simple. — Near *Pyrola?*

Ericoideae, fr. a septicidal capsule, or nut. Corolla persistent. *Erica, Calluna.*

Vaccinioideae (*Vacciniaceae* BH 92, of WARMING, of HUTCHINSON). Ovary inferior, fr. a berry or drupe; inc. *Vaccinium* (blueberry and cranberry), *Gaylussacia* (huckleberry); mostly on mts. in tropics, some common northward; *Thibaudia.*



Empetraceae. — *Corema Conradi,* dioec.; a: ste. fl., sepals 3-5, sts. 3, anthers brown, extrorse; b: carp. fl., stigma laciniate; c: ovary, four- or mostly three-celled, plac. axile; d: various attachments of ovules.

74. EPACRIDACEAE

Shrubs or small trees; mainly temp. Australia and New Caledonia reaching Malaya. Hawaiian Is., s. S. Am.: gen. 20.

Lvs. usually small, stiff, often with sheathing bases. Calyx 5-4 parted, persistent; corolla 4-5 lobed. Sts. 4-5, mostly epipetalous, anthers mostly 2-celled, opening by single cleft. Carpels 4-5, ovary 1-10 cells, ovules 1-many; style 1, stigma 1. Fr. a loculicidal capsule, or drupe; embryo straight, in endosperm. — *Epacris, Prionotes, Sprengelia,* etc., sts. free, anthers opening by two clefts. — BH 95, TH 234.

75. EMPETRACEAE (Crowberry Family)

Low, heath-like shrubs, in cold and temp. zones; gen. 3; ***Empetrum nigrum*** throughout northern regions in N. Am., Eur., and Asia; *E.* ***rubrum*** in s. S. Am.

Lvs. small, linear, revolute, evergreen; exstipulate. Monoec., dioec. or polygamous; fls. small. Sepals 2-3, petals 2-3, sts. 2-3. Ovary 2-9 celled, globose, ovule 1 in each cell. Fr. a small black drupe. Endosperm abundant.

BH 162, TH 150.—SAMUELSSON, 1913: ENGLER'S *Parietales, Geraniales, Sapindales* are heterogenous orders; but *Bicornes* or *Ericales* is a natural order; including at least *Ericaceae, Clethraceae, Epacridaceae, Pyrolaceae; Empetraceae* also belong with these as shown by embryogeny, esp. development of endosperm, which is like *Ericales,* not like *Geraniales* or *Sapindales. Cyrillaceae, Polygalaceae* and *Callitrichaceae,* position in ENGLER system doubtful; *Diapensiaceae* and *Lennoaceae* doubtful members of *Ericales. Empetrum-Ericaceae* relation suggested by JUSSIEU, also by AGARDH, and ASA GRAY; confirmed by the rust genus *Chrysomyxa.*—According to WETTSTEIN all *Ericales* might be one family.— HAGERUP, 1922.—GOOD, 1927: *Empetrum* nearly everywhere N. of Lat. 40°; in S. Hem. Juan Fernandez to Fuegia, on Falkland Is. and Tristan de Cunha; not in Australasia.

76. DIAPENSIACEAE

Low evergreen shrubs; from N. Carolina northward, also in Himalayas and E. As.; gen. 6; *Diapensia* circumpolar.

Lvs. simple, exstipulate. Fls. perfect, regular. Calyx usually 5 sepals, 2 smaller, corolla 5-parted. Sts. 5, epipetalous, often also 5 staminodia, anthers opening longitudinally. No disk. Ovary 3-celled, ovules many. Fruit a loculicidal capsule, like *Ericaceae.* Endosperm abundant, embryo cylindric, cotyledons very short. Seed coat 1.

BH 96, TH 235.—SAMUELSSON, 1913: Family doubtfully near *Ericaceae;* endothecium present, not in *Ericales* proper.

ROSALES

Calyx usually 5-parted, petals and sts. usually perigynous, petals probably staminodial, carpels separate, endosperm none.

Chromosomes:

Crassulaceae—*Sedum* 4, 5, 6; *Crassula* 7, 8, 17; *Sempervivum* 15, 18.—BALDWIN, 1937: *Sedum, Telephium* Section, chromosome numbers divisible by 10, 11, 12; basic number perhaps 12 or 6.

Leguminosae—*Caesalpinia, Haematoxylon, Tamarindus* 6.—SENN, 1938: Basic chromosome number 8, other 7, 12 and various; in this family herbaceous plants, especially annuals, have lower chromosome numbers; supporting MUNTZING, 1936.

Mimosaceae—*Mimosa* 12, *Albizzia* 12, 13; *Acacia* 13.

Pomaceae—*Crataegus, Cydonia, Mespilus, Malus, Pyrus, Sorbus, Aronia, Photinia,* all 17.

Rosaceae—*Rosa, Geum, Potentilla, Fragaria, Rubus, Agrimonia* 7; *Alchemilla, Exochorda, Prunus, Prinsepia* 8; *Spiraea, Kerria, Rhodotypos* 9.—SHIMOTOMAI, 1930: *Potentilla* haploid chromosomes 7 and exact multiples of 7; in Section including *P. fruticosa* 7, probably a primitive group.

77. CRASSULACEAE (Orpine Family)

Mostly succulent herbs or small shrubs, Cosmopolitan; gen. 20.

Infl. cymose. Sepals 5-4, rarely 3-30, sometimes connate. Petals same number. Sts. as many or twice as many. Scales or nectaries at base of carpels. Carpels as many as petals, free or united. Ovules usually many. Fruit of follicles. Seeds small, with some endosperm.—*Cotyledon, Bryophyllum, Kalanchoe, Rochea,* sympetalous; *Penthorum,* apetalous.

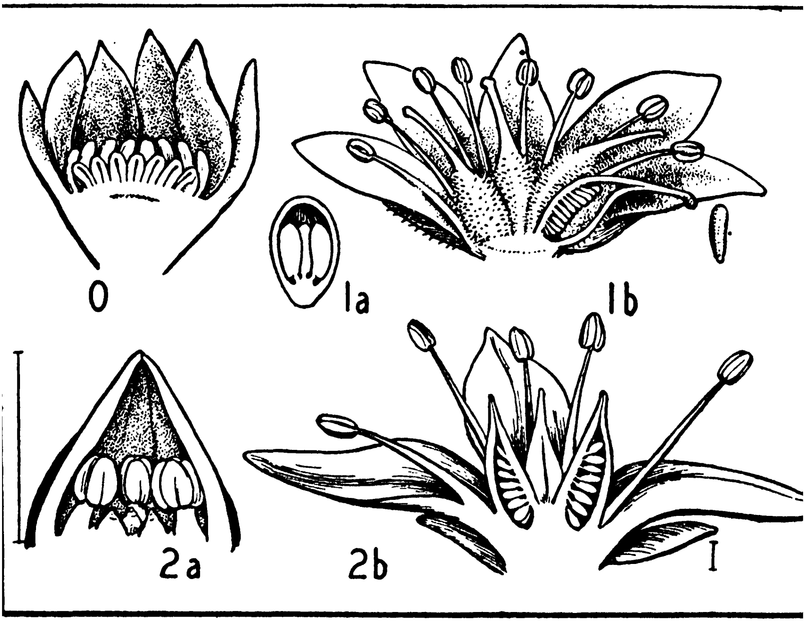
BH 60, TH 115.—SOUÈGES, 1927: Earliest embryo development suggests *Sagina* (*Caryophyllaceae*); general development resembles *Hypericum* and *Cruciferae.*—ROCEN, 1928: *Penthorum* not succulent; carpels united; embryology indicates it should be subfamily.—BERGER, Pflfam. 1930: *Crassulaceae* very natural family, near *Saxifragaceae.*—MAURITZON, 1930, 1933.

78. CEPHALOTACEAE

Cephalotus, Australian insectivorous perennial herb; in swamps, S. W. Australia; sp. 1.

Lvs. of two kinds: some flat, others composed of petiole and pitcher with lid, suggesting *Nepenthes*. Perianth 6-parted. Sts. 12. Carpels 6, free, ovules 1-2 in each carpel, basal. Fruit dry; embryo small, in endosperm.

TH 116. — Schweiger, 1909: Detailed comparison *Sarracenia* and *Cephalotus;* enumerates resemblances and differences, concludes they are not related. — Macfarlane, Pflreich. 1911: Quotes Goebel, "it seems absolutely probable *Cephalotus* is related to *Sarracenia*." — Diels, Pflfam. 1930: Pitcher development of *Cephalotus* and *Nepenthes* different.



Crassulaceae. — 0 and 1, *Sempervivum* sp.; a: bud, *S. arachnoideum;* b: fl., carpels pubescent, sts. twice as many. — 2, *Sedum roseum;* a: bud; b: adult fl.

79. CROSSOSOMACEAE

American small shrubs; one sp. s. w. Calif. and Lower Calif.; another Catalina and Guadeloupe Is.; gen. 1.

Lvs. alt., grayish. Fls. solitary, large, white. Sepals 5, tubular at base, petals 4, orbicular. Sts. 15-20, free, on calyx tube. Carpels 3-5, free, stigmas oblique, discoid. Seeds many, globose, with aril; embryo slightly curved, endosperm thin.

TH 125. — Fam. Engler, 1897.

80. ROSACEAE (Rose Family)

Herbs, shrubs, trees; world-wide distribution, chiefly in N. Temp.; gen. 80; inc. *Rubus* (raspberry, blackberry), *Fragaria* (strawberry), *Prunus* (peach, apricot, plum, cherry); many ornamental plants.

Vessel perforations nearly all simple. Lvs. simple or compound, stipulate. Fls. regular, perigynous or epigynous. Calyx cup 5 or 4 parted, often with outer bracts; petals same number. Sts. usually many, in several whorls; calyx, petals and sts. form a floral tube. Carpels usually separate, 2 or more ovules in each. Embryo with thick cotyledons, seed coats 2, endosperm usually none.—*Alchemilla,* filament jointed like *Euphorbia,* also chalazogamy; *Neillia* carpel one; *Lindleya* carpels fused.

Prunoideae (*Drupaceae* or *Amygdalaceae*). Carpel single.

BH 58, TH 126.—BONNE, 1928: Calyx cup mostly appendicular. *Quillajeae* ancestral type; *Neuradoideae* and *Chrysobalanoideae* should be separated from *Rosaceae*.—BOULENGER, 1931: European roses earliest in fl. are boreal and mountain spp., probably more primitive.—JULIANO, 1931: *Lyonothamnus* intermediate between *Saxifragaceae, Rosaceae* and *Cunoniaceae.* —JACKSON, 1934: The terms calyx tube, receptacle tube and hypanthium are misleading; floral tube is better for fused basal parts other than carpels.

81. CHRYSOBALANACEAE

Evergreen woody plants, mostly S. Am.; gen. 12.

Anatomy distinct. Lvs. simple, entire. Fls. mostly zygomorphic, style gynobasic.

Chrysobalaneae R. BROWN.—BONNE, 1926: Typical trimerous ovary of 1 fertile, and 2 abortive locules, latter represented by slits in style; genus *Chrysobalanus,* with 2-carpel ovary, is more reduced.

82. POMACEAE (Apple Family)

Small trees and large shrubs, chiefly N. Temp.; gen. 18; *Malus* (apple), *Pyrus* (pear), *Cydonia* (quince), *Eriobotrya* (loquat), *Mespilus* (medlar), *Sorbus* (mountain ash), *Crataegus* (hawthorn).

Lvs. simple or pinnate, stipulate. Calyx 5-parted, petals 5, as in *Rosaceae;* but ovary inferior. Sts. usually 10+5+5 or 10+10+5. Floral axis a deep cup; carpels united with it and with each other; each carpel usually with two ovules, but single seed. Fruit a pome. — *Stranvaesia,* ripe carpels separate; *Osteomeles,* n. S. Am.

Pomaceae, JUSSIEU, 1789, of DC 1825, of KOEHNE, of WARMING; BH, TH sub *Rosaceae.*—SAX, 1923: Basic chromosome number in *Rosoideae* is 7, also 8; in *Spiraeoideae* 8 and 9. *Pomoideae* with number always 17, form a distinct and closely related group; probably the largest and most diverse single group of plants for which allo-polyploid origin has been clearly established.

83. PLATANACEAE (Plane Tree Family)

Large trees; *Platanus orientalis,* Himalayas to e. Medit.; *P. occidentalis,* Mexico, e. U. S., e. Canada; other American spp.; gen. 1.

Vessel perforations scalariform and simple. Bark peeling in large plates. Lvs. long-stalked, palmately veined; bud covered by swollen petiole. Stipules large, falling early. Monoec.; fls. in crowded spherical heads, which are really condensed panicles; rudiments of other sex often present. Ste. fls. with 1 scale; connective peltate, like *Annonaceae.* Carp. fls. of 1 carpel, with bracts; ovule 1, pendulous, endosperm scanty. Seed coats 2. Fr. an akene, with long hairs.

BH 154, TH 124. — GRIGGS, 1909: Fls. apetalous, transitory scale around sts., 3-4 hairy staminodes around carpels; near *Moraceae;* obvious characters are the significant ones. — BROUWER, 1924: Family entirely isolated among angiosperms; WETTSTEIN placed it with *Hamamelidaceae* before *Ranales;* I. W. BAILEY notes special foliar rays system. Indiv. fls. of single st. and adherent carpel, but in whorls to simulate a flower. — BRETZLER, 1924: Illus. ovule.—SCHONLAND, 1927: Fl. structure is against BROUWER's interpretation. — BOOTHROYD, 1930: Near *Spiraea* and primitive *Rosaceae;* approves WETTSTEIN view, that *Hamamelidaceae* are near *Urticales; Platanus* fl. structure result of wind-pollination: abundant pollen, size of anther, long stigma, reduction of perianth, unisexuality; reduction shown by morphology and by anatomy. Sepals fused in *P. occidentalis,* free in *P. orientalis.* In ste. fls. calyx usually 4-parted, petals 3-4. Carpels 5-9 in 2-3 whorls; fr. a follicle.

84. CONNARACEAE

Trees and shrubs, many climbing, Trop. Am., Afr., Asia; gen. 20.

Lvs. alt., odd-pinnate, exstipulate; leaflets leathery, entire. Fls. small, calyx 5-parted, petals 5, free, sometimes slightly connate. Sts. 5-10, often connate at base. Carpels usually 5, separate, ovules 2, orthotropous; fr. usually single carpel, with single seed. Seed often with colored aril. — HUTCHINSON near *Anacardiaceae.*

BH 56, TH 127. — SCHELLENBERG, Pflreich. 1938: Fruit a legume, *Jollydora* 2-seeded, others 1-seeded; stipules none, though nearly universal in *Rosaceae* and *Leguminosae;* certainly near *Rosaceae,* perhaps near *Oxalidaceae.*

85. MIMOSACEAE (Mimosa Family)

Trees and shrubs, often spiny; rarely herbs; Trop. and Subtr.; gen. 40; *Acacia,* mostly old world, *Mimosa* (inc. sensitive plant), mostly Am.

Lvs. usually twice-pinnate, stipulate, in *Inga* and *Affonsea* once pinnate. Infl. dense; fls. usually small, regular, petals valvate, often united or absent. Sts. many; filaments long, free (*Des-*

manthus, Entada), often colored; or connate (*Albizzia, Prosopis*). Aril sometimes present.—WETTSTEIN recognized *Mimosaceae*, not *Caesalpinaceae*.

BH, TH sub *Leguminoseae*; *Mimoseae*, R. BROWN, 1814.—NEWMAN, 1933: Development, spore production and chromosomes in *Acacia* suggest that inflorescence is more important than leaf characters.

86. LEGUMINOSAE (Pea Family)

Trees, shrubs, herbs; Cosmopolitan; gen. 500; second largest family of dicotyledons; numerous useful plants, incl. pea, bean, lentil, peanut, licorice, logwood, tamarind, clover, alfalfa; locust, Kentucky coffee tree, yellowwood.

Lvs. alt., usually pinnate, stipulate; daily leaflet movement frequent. Calyx mostly tubular. Carpel usually single. Fr. a legume, that is a pod, dehiscing by both ventral and dorsal sutures, often jointed. Seed without endosperm, cotyledons usually come above ground.

Caesalpinioideae (*Caesalpineae* R. BROWN, 1814). Fls. zygomorphic; upper petal inside, sts. mostly 10, often free. *Kramerieae* (*Krameriaceae* DUMORTIER 1829). Glands in place of two petals; anthers with apical pores.

Papilionatae (*Papilionaceae* or *Fabaceae*). Fls. papilionacous, upper petal exterior, 2 lower connate, forming keel; sts. often 10, 9 united and 1 free, or all united.—*Sophora* and others, sts. free.

BH 57, TH 128.—MCLEAN-THOMPSON, 1931: Comparisons and illustrations of fls. in *Leguminosae*, concludes ancestors had many carpels; numerous lower sterile parts of ancestral leguminous fl. probably leaflike, grading upward to many spirally arranged sts.; fl. apetalous, with branched gynoecium.—MOORE, 1936: Floral anatomy, in *Phaseolus* tribe perianth, st. and disk traces on same radius are fused, departing as unit from stele; in other tribes perianth and st. traces are separate.

HAMAMELIDALES

Chromosomes:

Hamamelidaceae—*Corylopsis, Distylium, Fothergilla, Hamamelis,* all 12: *Liquidambar* 15—ANDERSON and SAX, 1935: Chromosomes small; basic numbers 12, 36, 24, 15: cytologically strong resemblance to *Rosaceae,* also near *Saxifragaceae.*

Hydrangeaceae—*Ribes* 8, *Itea* 11, *Deutzia, Philadelphus* 13; *Jamesia* 16, *Hydrangea* 18.

Pittosporaceae—*Pittosporum* 12.

Podostemaceae—*Weddelina* 20.

Saxifragaceae—*Astilbe, Heuchera, Tellima, Tiarella* 7; *Adoxa, Parnassia* 9; *Saxifraga* 7, 8, 9, 11, 13; *Francoa* 13.

WETTSTEIN'S *Hamamelidales* includes *Hamamelidaceae, Cercidiphyllaceae, Eupteleaceae, Platanaceae* and doubtfully *Myrothamnaceae.* HUTCHINSON'S *Hamamelidales* includes *Bruniaceae, Stachyuraceae, Hamamelidaceae, Eucommiaceae, Myrothamnaceae, Buxaceae, Platanaceae.* In this book *Rosales* includes families with mostly separate carpels, little or no endosperm; *Hamamelidales* those with carpels united, mostly with small embryo in abundant endosperm; separation not clear.

87. STACHYURACEAE

Asiatic shrubs and small trees; China, Japan, Himalayas; gen. 1.

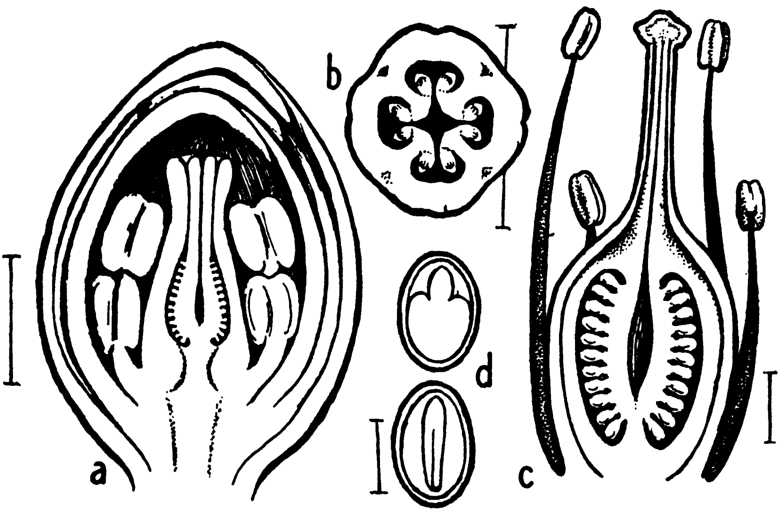
Vessel perforations scalariform. Pith large. Lvs. alt., glabrous, serrate, exstipulate. Fls. in axillary spikes, pendulous, yellowish. Sepals 4, petals 4, imbricate; stipules small. Sts. 8, free. Ovary 4-celled, style 1, stigma 4-lobed, ovules many. Fr. a 4-celled berry, pericarp leathery; seed with aril and endosperm, embryo straight.

TH 200.—GILG, family, 1893; Pflfam. 1925: Like *Actinidiaceae* in fruit, seed, aril; different in isomery and ovary; BAILLON said first near *Clethraceae,* later near *Flacourtiaceae.*—*Stachyurus* habit, lvs., fls. suggest *Corylopsis.* HUTCHINSON placed family before *Hamamelidaceae;* TIPPO says wood anatomy very similar in these two families.

88. HAMAMELIDACEAE (Witch-Hazel Family)

Trees and shrubs; Atlantic N. Am., Himalayas to s. e. Asia, a few in Madagascar and S. Afr.; gen. 18; *Liquidambar* (Sweet Gum); *Altingia,* very large tree, s. e. Asia.

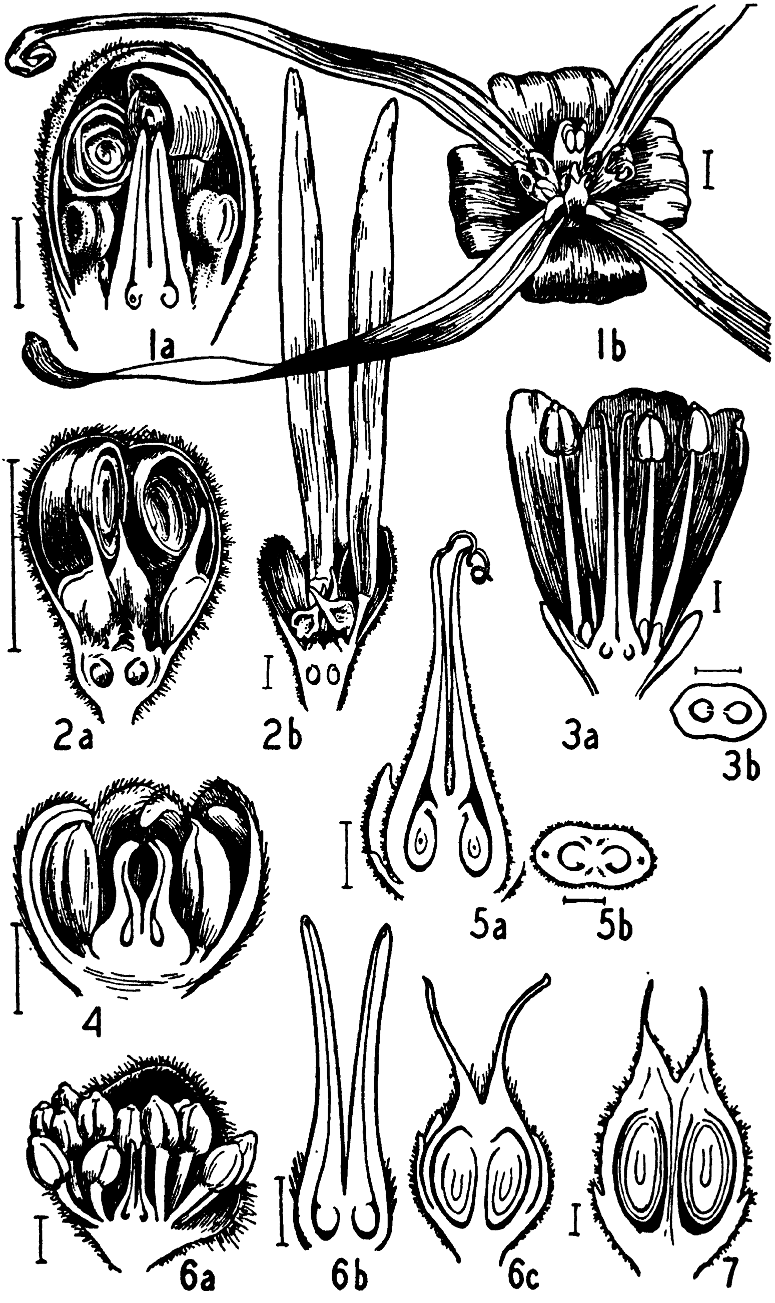
Vessel perforations exclusively scalariform; lvs. alt., simple, stipules deciduous; pubescence stellate, resembling *Hydrangeaceae.* Infl. a spike or head, sometimes with petaloid bracts (*Parrotiopsis*); fls. often small; *Rhodoleia* infl. flower-like. Sepals 4-5, petals 4-5. In petaloid fls. staminodes 4-5, sts. 4-5, connective projecting, in apetalous fls. sts. numerous. Carpels 2, united below. Ovary often half-inferior. Fr. a hard, 2-celled capsule. Seeds sometimes winged, embryo large, in endosperm. — BH 62, TH 123.



Stachyuraceae. — *Stachyurus chinensis;* a: bud; b: sec. young ovary; c: fl., sts. 8, 4 long and 4 short, plac. parietal, axile below, stigma 4-lobed; d: seed as in *Idesia.*

Liquidambar and *Altingia,* sometimes separated as *Altingiaceae:* Trees, monoec., wind-pollinated; sts. in clusters without perianth; filaments short or none; carp. fls. in heads with small epigynous calyx; *Liquidambar* lvs. palmately veined.

Shoemaker, 1905: *Hamamelis virginiana* fertilization in May, half year after pollination; seeds sprout after lying on ground two winters; formerly doubtless early spring-flowering (like Asiatic sps.). — Horne, 1914: *Hamamelidaceae, Cornaceae, Caprifoliaceae* probably related; single surviving seed parietal in *Hamamelidaceae,* axile in *Caprifoliaceae.* Evidence not yet accumulated for the synthesis that Hallier attempted too early; result, the extreme instability of his system. — Harms, Pflfam. 1930: Lindley united *Hamamelidaceae* and *Bruniaceae,* placed after *Cornaceae;* Baillon, also Hallier, derived *Corylus* from *Corylopsis;* Eichler opposed. — Tong, 1930: *Corylopsis* characters primitive.


1a
1b
2a
2b
3a
3b
4
5a
5b
6a
6b
6c
7

89. MYROTHAMNACEAE

Low shrubs; Trop. and S. Afr., Madagascar; gen. 1.

Vessel perforations scalariform. Twigs quadrangular; lvs. opp., stipules small. Dioec.; fls. in spikes, perianth none. Sts. 4, 5, or 8, filaments connate, connective projecting. Ovary 3-celled, ovules many, in double rows. Seeds small, pendulous, embryo small, endosperm abundant.

TH 121. — NIEDENZU, family, 1891. — NIEDENZU-ENGLER, Pflfam. 1930: Very near *Cunoniaceae,* but wind-pollinated; special epidermis cells.

90. BRUNIACEAE

Low, heath-like shrubs; S. Africa; gen. 12.

Lvs. small, entire, exstipulate. Fls. small, in spike or head. Bracts 5, calyx 4-5 parted, petals 4-5. Sts. 4-5, sometimes connate with petals. Ovary half-inferior or inferior, 1-3 cells; ovules 1-2, pendulous from apex. Seeds small, embryo small, seed coat 1; endosperm abundant.

BH 63, TH 122. — NIEDENZU and HARMS, Pflfam. 1930: VAN TIEGHEM says family is near *Cornaceae.*

91. CUNONIACEAE

Trees and shrubs; mostly Australasia, some S. Am. to Mexico, 1 in S. Afr.; gen. 25.

Vessel perforation scalariform in *Cunonia* and *Weinmannia,* scalariform and simple in *Ceratopetalum* and *Brunellia.* Lvs. opp. or in whorls, usually compound, often glandular-serrate, stipules interpetiolar. Fls. small, sepals 4-5, petals 4-5 or none. Sts. 4-5-many, from beneath disk. Ovary mostly 2-celled, styles 2, free; plac. axial or apical, sometimes carpels free. Embryo straight, in endosperm. — In *Spiraeanthemum* carpels 5, ovaries separate, but styles coherent.

TH 120. — ENGLER, Pflfam. 1930: Near *Saxifragaceae,* but family justified by fl. structure, large stipules and distribution.

Hamamelidaceae. — Stellate pubescence frequent in *Hamamelidaceae, Hydrangeaceae, Araliaceae.* 1, *Hamamelis mollis;* a: sepals, inrolled petals, sts.; carpels two, connate below, ovules axile, pendulous; b: fl., sepals reflexed, petals linear, staminodes small, sts. with bent projecting connective, ovary half inferior. — 2, *Loropetalum sinense;* a: bud, connective conspicuous, staminodes fringed; b: fl. ovary inferior. — 3, *Corylopsis spicata;* a: fl., connective slightly projecting, styles long; b: sec. ovary, plac. axile. — 4, *Fortunearia sinensis;* sec. bud. — 5, *Parrotia persica,* fl. apetalous; a: longit. sec. of ovary, styles slender, stigmas linear; b: cross sec. — 6, *Fothergilla major;* a: bud, sts. numerous, filaments tapering; b: ovary, later; c: fr., embryo straight in endosperm. — 7, *Parrotiopsis Jacquemontiana,* fr.; calyx lobes small.

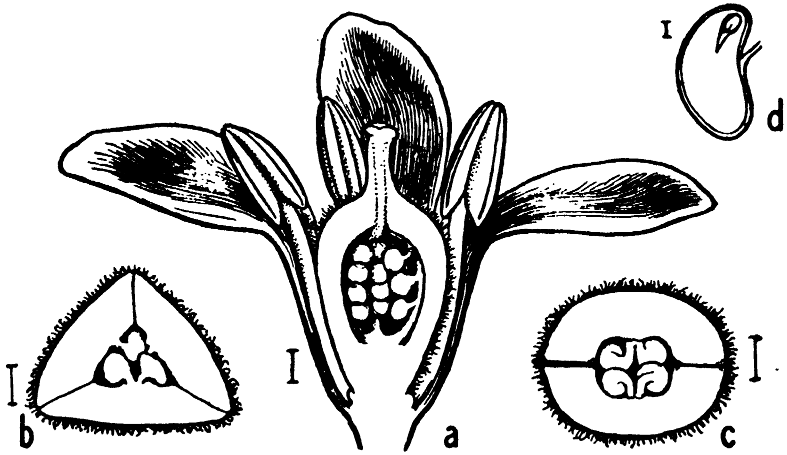
Brunellia Subfam.? (*Brunelliaceae* fam. ENGLER, 1897, and Pflfam. 1930; BH sub *Simarubaceae*, TH 119). Trees, spiny or tomentose; Mexico to Peru. Dioec., carpels 2-5, separate, ovules suspended, each carpel 1-2 seeds.

92. PITTOSPORACEAE

Trees, shrubs, woody climbers; all in Australia; *Pittosporum* also in Trop. As. and Afr., Pacific Is.; gen. 9.

Lvs. alt. or whorled, exstipulate. Sepals 5, often connate, petals 5, claws sometimes coherent. Sts. 5. Carpels usually 2, plac. parietal or axile, style 1. Seeds many or few in pulp or viscid juice; small embryo eccentric in abundant endosperm. — Near *Escallonioideae* (*Saxifragaceae*), differ in resin passages in cortex.

BH 18, TH 118. — SCHÜRHOFF, 1929: Resin ducts, carpels 2, seed coat 1, pollen with 3 nuclei, endosperm nucleate; agrees with VAN TIEGHEM that family belongs near *Umbelliferae*, not near *Saxifragaceae*. — PRITZEL, Pflfam. 1930: BAILLON as subfamily in *Saxifragaceae;* not near *Polygalaceae* or *Rutaceae*, on account of ovule.



Pittosporaceae. — *Pittosporum Tobira;* a: fl., sepals fallen, petals with claws, anthers introrse, ovary pubescent, plac. parietal; b: three-celled ovary, pubescent; c: two-celled ovary; d: ovule, embryo small, in endosperm.

93. BYBLIDACEAE

Glandular herbs; W. and N. Australia; gen. 1.

Lvs. linear or threadlike. Fls. solitary, or few in racemes. Sepals 5, free, petals 5, slightly connate, twisted. Sts. 5, anthers opening by apical pores or short slits. Ovary 2-3 celled, ovules several; style 1, stigma capitate. Fr. a globular capsule; seed coat 1, endosperm present.

BH, TH sub *Droseraceae.*—DOMIN, 1922, fam. nov., near *Pittosporaceae.*—DIELS, Pflfam. 1930: Near *Pittosporaceae,* both in fl. and fr., especially like *Cheiranthera,* but in *Byblidaceae* no resin-ducts; also ovules are different.

Roridula (*Roridulaceae,* MARLOTH, fam., 1925, BH, TH sub *Droseraceae*). African mtn. shrubs; s. e. Afr., gen. 1.—Lvs. narrow, with sticky, glandular hairs. Sepals 5, petals 5, sts. 5. Carpels 3, plac. axile, ovules 1-several. Fr. a loculicidal capsule; seeds with sticky epidermis, endosperm abundant, oily, embryo straight.—DIELS, Pflfam. 1930: *Roridula* isolated; long-stalked glands and sticky secretions; HUTCHINSON includes it under *Byblidaceae.*

94. HYDRANGEACEAE

Shrubs or small trees; temp. N. and S. Am., e. Asia, Australia; gen. 40.

Vessel perforations mostly scalariform, lvs. mostly exstipulate. Calyx lobes 5-4, petals 5-4. Sts. numerous, twice as many as petals, or the same number. Ovary of 2-5, rarely 10 carpels, plac. mostly axile. Seed with endosperm.

Iteoideae (*Iteaceae*), gen. 1. Lvs. alt., ovary superior, carpels 2. In the other subfamilies the ovary is inferior or half-inferior.

Baueroideae, gen. 1. Lvs. trifoliolate, carpels 2, plac. parietal; Australia.

Pterostemonoideae, gen. 1. Lvs. alt., stipulate.

Escallonioideae (*Escalloniaceae*). Lvs. alt., often leathery and glandular-toothed, seed coat 1.

Hydrangeoideae. Lvs. opp., pubescence stellate, inc. *Hydrangea, Deutzia, Philadelphus.*

Ribesioideae (*Grossulariaceae* or *Ribesiaceae*), gen. 1. Lvs. alt., usually palmately lobed, petals small, plac. parietal, fr. a berry.

BH, TH sub *Saxifragaceae.*—HUTCHINSON and DANDY, 1927: Phylogeny of *Hydrangeaceae* and *Saxifragaceae: Hydrangea, Parnassioideae* and *Francoideae* have commissural stigmas like *Papaveraceae; Vahlia* with apical plac. suggests *Oldenlandia* (*Rubiaceae*).—ENGLER, Pflfam. 1930: *Saxifragaceae* (inc. *Hydrangea,* etc.) nearest to *Crassulaceae* and *Cunoniaceae;* also near *Hamamelidaceae;* and through *Astilbe-Spiraea* to *Rosaceae.*

95. SAXIFRAGACEAE (Saxifrage Family)

Herbaceous plants; Cosmopolitan, mainly in cold and temp. regions; gen. 35.—Generic limits often uncertain.

Lvs. mostly alt. or basal, usually exstipulate. Fls. hypogynous, perigynous or epigynous. Sepals usually 4-5, connate below. Petals same number, inserted with sts. at edge of nectariferous disk, sts. partly united. Placentae swollen, with rows of anatropous ovules. Embryo small, endosperm abundant.—In *Vahlia* lvs. opp.

Francoideae (*Francoaceae* of MÖBIUS). Chilean herbs, fls. mostly 4-parted.

Adoxoideae (TH 272). *Adoxa moschatellina,* small perennial herb, musk-scented, in northern, alkaline-soil woodlands around the world: Minn., Wis., Catskill Mts., Siberia, Europe. Lvs. 2, basal, opp., ternately compound, scape with a pair of similar smaller lvs. Fls. small, greenish, in capitate cluster. Involucral tube reaches nearly to summit of 3-5 celled ovary. Perianth salverform, 4-6 lobed, with 8-12 spreading sts., in pairs. Filaments short, anthers 1-celled. Style 3-5 parted. Fr. a dry greenish drupe, 3-5 nutlets, each with 1 seed, with endosperm.

BH 59, TH 117. — Sprague, 1927: *Adoxa* (TH 272) has bulb-like expansion of rhizome, lvs. ternately divided. Involucre and calyx is simpler interpretation than calyx and corolla; abnormal infls. and fls. confirm this. Semi-epigynous, apetalous fls. with distinct indications of former presence of second whorl of sts. seem sufficient to exclude it from *Rubiales.* By external characters nearest to *Saxifragaceae,* anatomically nearest to *Caprifoliaceae.* — Schoennagel, 1931: *Saxifragaceae* chromos. 7 or 8, same as *Rosaceae,* but *Francoa* 26; *Parnassia* should be excluded from family.

96. PODOSTEMACEAE (River weed Family)

Submerged aquatics on stones in running water; mostly trop. Am., also trop. Asia and Afr.; gen. 20.

Stem and lvs. confluent, alga-like fronds. Fls. small, buds often in spathe of connate bracts. Sepals 2-3, small, connate below; petals none. Sts. 1-many. Carpels 2-3, styles 2-3, plac. axile. Fr. a capsule; seeds many, small, endosperm none.

BH 135, TH 113 as *Podostemonaceae.* — Engler, Pflfam. 1930: Position doubtful; perhaps near *Saxifragaceae.* — Mauritzon, 1933: Probably near *Crassulaceae* and *Saxifragaceae.*

97. HYDROSTACHYACEAE

Submerged fresh water herbs; S. Africa and Madagascar; gen. 1.

Stem tuber-like, lvs. simple to 2-3 times pinnate. Dioec.; fls. in dense spikes, perianth none. Ste. fl. with bract, st. 1. Carpels 2, styles 2, plac. parietal. Fr. a small capsule. Ovules many, endosperm none, seed coat 1.

TH 114. — Family Warming, 1891. — Mauritzon, 1933: Probably near *Podostemonaceae.*

THYMELAEALES

Dry climate plants, many S. Hemisphere, lvs. usually small, exstipulate, calyx often colored, carpel usually one, seed often single.

Chromosomes:
Elaeagnaceae—*Elaeagnus* 7 or 14, *Hippophae* 10, 12, *Shepherdia* 11, 13.
Thymelaeaceae—*Daphne, Edgeworthia, Wikstroemia* 9.

98. PENAEACEAE

Small, heath-like shrubs, S. Afr.; gen. 5.

Lvs. opp., entire, stipules minute. Fls. small, single in upper leaf-axils. Bracts often colored, 1 or more pairs bracteoles. Calyx tubular, 4-lobed, mucronate, petaloid, veins parallel; petals none. Sts. 4 on throat, connective thick. Ovary, 4-celled, 4 stigmas, ovules 2-4 in each cell. Fr. a loculicidal capsule included in persistent calyx; seed often single in each cell, embryo thick, cotyledons small, endosperm none.—BH 146, TH 212.

Geissoloma, low shrub; mts. S. Afr. (*Geissolomaceae* SONDER 1850, *Geissolomataceae* of TH, of HUTCHINSON, of DIELS).—Bracts in unequal pairs, perianth segments nearly separate, sts. 8, ovary cells narrowly winged. Embryo with linear cotyledons in endosperm.

99. OLINIACEAE

African shrubs or small trees, e. & s. Afr., S. Helena; gen. 1.

Branches quadrangular; lvs. opp., exstipulate. Calyx tubular, extending beyond ovary, with usually 5 small lobes. Petals 5 or 4, at calyx throat. Sts. 4-5 on calyx tube, filament very short, thickened connective projecting. Ovary inferior, 3-5 celled, style with thickened stigma; ovules axile, pendulous. In fr. each cell 1-seeded; seed coats 2, cotyledons folded, endosperm none.—TH 213.—Differs from *Penaeaceae* in inferior ovary and presence of petals.

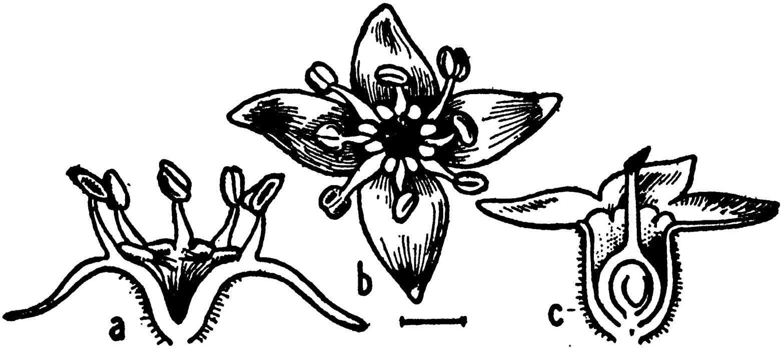
100. THYMELAEACEAE

Old World trees, shrubs, a few herbs; mainly S. Afr., Australia, Medit.; rare in Tropics; gen. 40.

Lvs. simple, entire, mostly small, exstipulate. Fls. small, calyx tubular, often swollen below, petaloid, 4-5 lobed. Petals 4-12, represented by scales, or none. Sts. as many as calyx lobes, or twice as many, disk sometimes present. Ovary nearly always 1-celled, 2-12 carpels, often raised on gynophore; ovule 1, anatropous, pendulous. Fr. a drupe, embryo straight; endosperm present or absent.

Gonystyloideae. (*Gonystylaceae,* TH 173). Trees, Malayan Region; gen. 1.—Lvs. alt., leathery, with characteristic veining, exstipulate. Calyx 5-lobed, petals many, linear, sometimes divided. Sts. many. Ovary usually 5-celled, style threadlike. Ovule pendulous, 1 in each cell. Fr. a woody capsule, seeds large, endosperm none.

BH 145, TH 214.—LEANDRI, 1930: Throat scales of petaloid nature; anatomy indicates family near *Elaeagnaceae* and *Rosaceae;* not near *Lythraceae,* or *Combretaceae.*



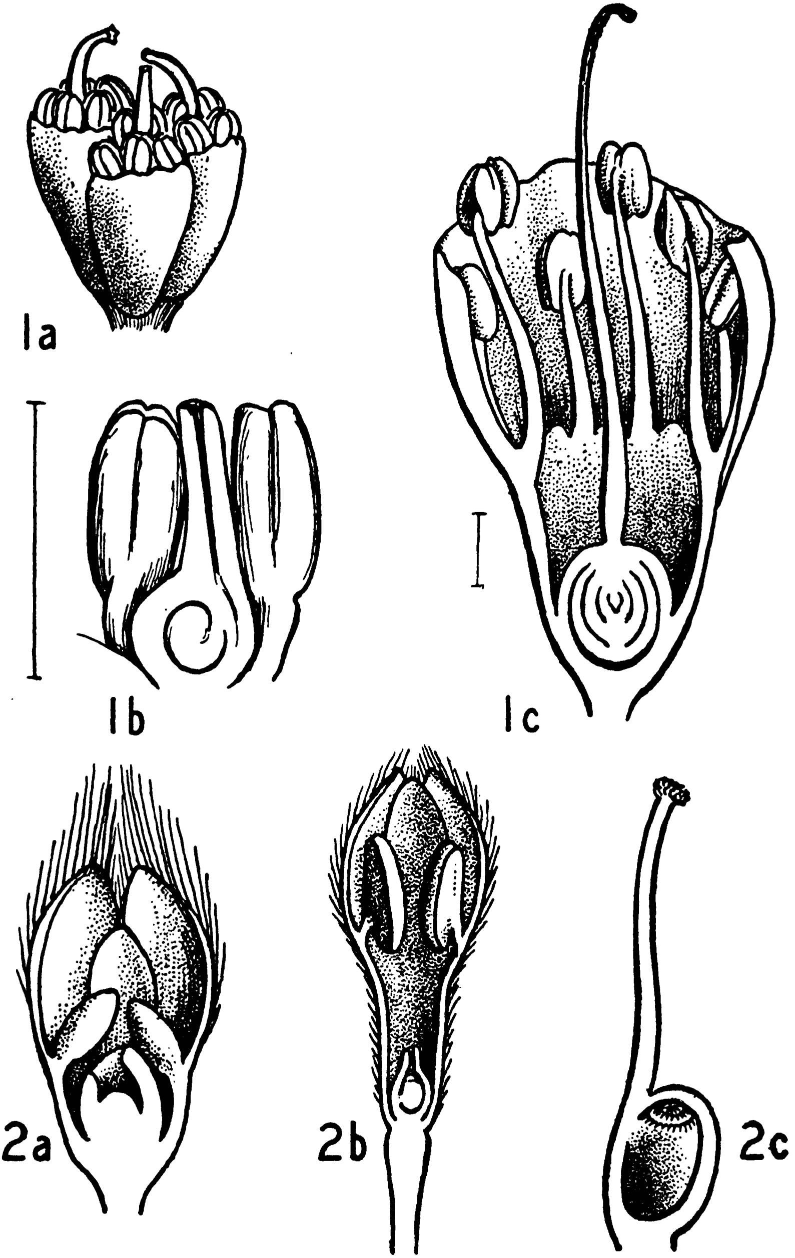
Elaeagnaceae.—*Shepherdia canadensis;* a, b: ste. fl., calyx four-parted, sts. four long, four short, eight small staminodes, all on thick disk; b: carp. fl.; c: calyx four-cleft, ovary half-inferior, style slender, stigma one-sided.

101. ELAEAGNACEAE (Oleaster Family)

Shrubs and trees, often spiny; chiefly in N. Temp. and Subtrop. Old and New Worlds; a few sp. of *Elaeagnus* in Tropics; gen. 3.

No intraxylar phloem. Plants covered with silvery and brown, peltate or stellate, scales. Lvs. simple, entire. Often dioec., fls. perigynous. Perianth single, tubular, petaloid, constricted above the free ovary; perianth lobes 4, rarely 2 or 6. Sts. same number or double, attached on calyx tube, disk prominent. Ovary 1-celled, ovule 1; style 1, stigma often capitate. Fr. dry, indehiscent, appearing drupe-like, because of enclosing fleshy perianth tube.

BH 147, TH 215.—SERVETTAZ, 1909: Monograph of family; nearest are *Thymelaeaceae* through *Elaeagnus, Penaeaceae* through *Hippophae* and *Shepherdia,* and *Proteaceae.*



Thymelaeaceae. — 1, *Dirca palustris;* a: infl. of few fls., b: sts. and carpel, one mm.; c: fl., ten mm., perianth single, sts. long and short on calyx tube, ovary half-inferior, style long, seed single, suspended, anatropous. — 2, *Pimelea ligustrina* (from Payer); a: bud, ovary open, one-sided; b: middle stage; c: adult ovary, style on one side, stigma capitate.

MYRTALES

Often with bicollateral vascular bundles. Lvs. mostly opp., often glandular. Fls. 4-parted (*cf. Rhodotypos*), ovary inferior, plac. axile.

Chromosomes:

Alangiaceae — Alangium 11.
Lythraceae — Peplis 5, *Cuphea* 6, *Lythrum* 15.
Melastomaceae — Melastoma 14.
Myrtaceae — Eugenia, Myrtus, Eucalyptus 11.
Nyssaceae — Nyssa 11.
Onagraceae — Clarkia, Gaura, Oenothera 7; *Circaea, Epilobium, Fuchsia* 18; *Trapa* 18?
Punicaceae — Punica 8, 9?

102. LYTHRACEAE (Loosestrife Family)

Shrubs, some trees, a few herbs; Temp., widely distr.; most abundant in Am. Tropics; gen. 20; *Lawsonia,* source of henna, orange dye.

Intraxylar phloem. Lvs. usually opp. or whorled, exstipulate. Fls. perigynous. Calyx tubular, enclosing ovary, but free, 4-8 lobed; appendages or petals between lobes, or none. Sts. usually 4 or 8, rarely numerous; often sts. and style heteromorphous. Ovary superior, 2-6 celled, ovules many, on axile placentae, sometimes not reaching top of ovary. Fr. a capsule. Embryo straight, endosperm none.

BH 69, TH 216. — Koehne, Pflreich. 1903: Lvs. entire; always tube between level of insertion of sts. and of petals; style simple. Close relation to *Onagraceae, Myrtaceae, Punicaceae, Combretaceae.*

103. HETEROPYXIDACEAE

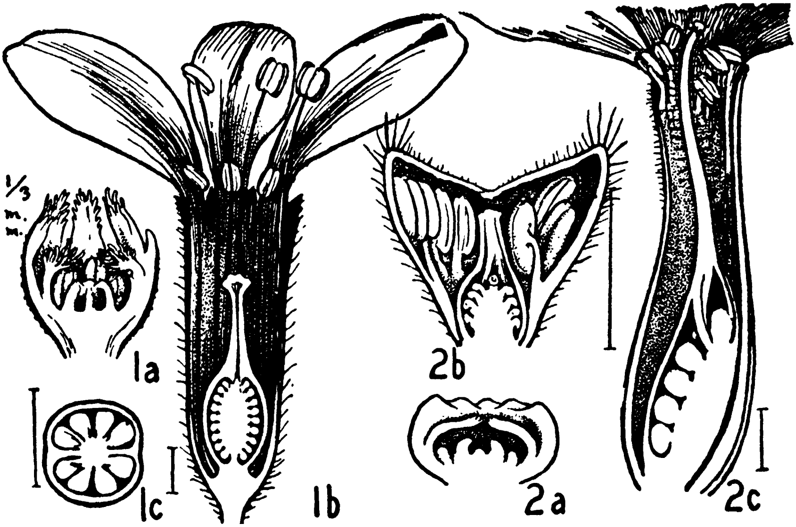
African trees; s. e. and e. Trop. Afr.; gen. 1.

Lvs. alt., pellucid punctate, exstipulate. Fls. in panicles, calyx 5-lobed, petals 5, on calyx tube with short claws, gland-dotted. Sts. 5, opp. petals. Ovary superior, 2-3 celled, style 1, with capitate stigma; ovules many, on axile placentae. Fr. a capsule, endosperm none.

104. SONNERATIACEAE

Mangrove vegetation; East Afr., Malay Region; trees, Trop. Himalayas; gen. 2.

Lvs. opp., leathery, entire, exstipulate. Fls. large, solitary or in three's. Calyx-tube thick, 4-8 lobed, petals 4-8 or none. Sts. numerous, perigynous or epigynous. Ovary 4-20 cells, ovules many, embedded in placentae. Fr. a capsule or berry, endosperm none. — TH 217.



Lythraceae. — 1, *Lythrum Salicaria;* a: in bud (one-third mm.) fringed scales between petals are nearly as large as petals; b: fl., calyx tubular, hairy, petals and sts. from lower calyx tube, sts. long and short, ovary slightly raised, style hollow, sts. and style trimorphous; c: ovary. — 2, *Cuphea lanceolata;* a: very young bud, ovary open, petals fringed; b: middle stage; c: fl., petals and sts. from calyx tube, ovary one-sided, plac. axile (suggestive of *Caryophyllaceae*).

105. CRYPTERONIACEAE

Asiatic trees; India, Malay Region, Philippines; gen. 1.

Branches 4-angled; lvs. opp., entire, exstipulate. Fls. very small, in long panicles. Perianth single, tubular, 4-5 lobed. Sts. 4-5. Ovary 2-celled, plac. axile, styles slender, ovules many. Fr. a capsule, seeds small, sometimes winged, endosperm none. — TH 217a.

106. LECYTHIDACEAE (Brazil nut Family)

Large trees in n. Brazil, African coasts, Malay Peninsula, Samoa; gen. 20; inc. *Bertholletia* (Brazil nut) and *Lecythis* (paradise nut or sapucaia).

Lvs. simple, sometimes with glands on margin, often very large, crowded at ends of branches, exstipulate. Vascular bundles separate in petiole, also distinct in midrib and large veins. Fls. often large; floral axis and ovary united, above ovary axis forms flat disk to which sts. and petals are attached. Calyx lobes 4-6, petals 4-6, or none, sometimes connate. *Napoleona* has no petals, but outer staminate whorl forms a conspicuous corona. Sts. many in several whorls, filaments form usually a one-sided cup. Ovary inferior or half-inferior, 2-6 cells. 1-many ovules on axile placentae. Fr. of Brazil nut a heavy wooden capsule. Endosperm none.

(*Barringtoniaceae*, KNUTH, Pflreich. 1939; fam. nov.; inc. *Napoleona;* opinions differ as to affinities; near *Lecythidaceae, Myrtaceae,* or *Symplocaceae.* — DIELS sub *Lecythidaceae.*)

(*Asteranthaceae,* KNUTH, Pflreich. 1939: fam. nov. Sp. 1, Brazil; corolla radiate; sts. many; epipetalous, DIELS sub *Lecythidaceae.*)

TH 219. — DIEHL, 1935: Crystal strands present in wood of American genera; absent in Old World genera except *Foetida;* family anatomically distinct from *Myrtaceae; Asteranthos* and *Napoleona* anatomically with *Lecythidaceae.*

107. RHIZOPHORACEAE (Mangrove Family)

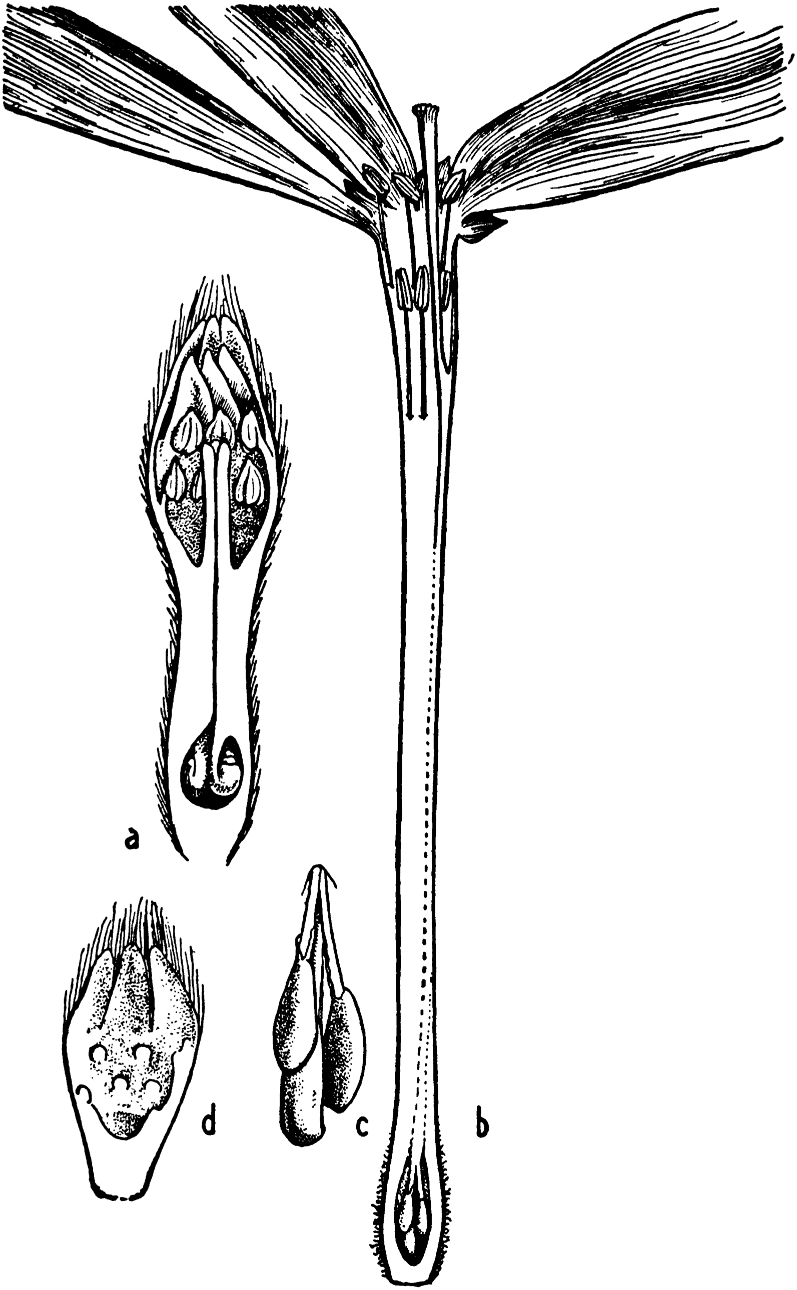
Remarkable trees and shrubs on mudflats along Trop. coasts; gen. 17.

Branches swollen at nodes; lvs. mostly opp., with stipules, simple, leathery. Fls. axillary, epigynous or perigynous. Calyx lobes 3-14, petals same number, often notched or lacerated, folded in bud. Sts. usually more than petals, often in pairs opp. petals. Ovary mostly inferior, 2-6 celled or 1-celled; usually 1 style. Ovules usually 2, inserted near apex of cells. Fr. a berry or drupe; seeds of *Rhizophora* germinate on plant. — BH 65, TH 220.

108. NYSSACEAE

Trees and shrubs, e. N. Am. and e. Asia; gen. 3; *Nyssa, Camptotheca; Davidia?*

Lvs. alt., simple, exstipulate. Dioec. or polygamous. Ste. fl.: calyx none, or of very small teeth; petals 5 or more. Sts. up to twice number of petals, disk present. Carp. fl.: calyx adnate to ovary, petals 5 or more, small. Ovary inferior, 1-celled; in Davidia 6-10 celled, disk often absent; ovule solitary, pendulous. Fr. often drupaceous, seed coats 2, endosperm little. — *Davidia* infl. with 2 large, white bracts.



Combretaceae.—*Quisqualis indica;* a: bud, sts. and petals from calyx, connective projecting, ovary inferior; b: fl., floral tube greatly lengthened, petals much enlarged, style attached to side of floral tube; c: seeds suspended by slender funicles; d: bud (from Payer).

WANGERIN, family, Pflreich. 1910: Differs from *Cornaceae* in diplostemony, double seed coat, pollen development; BAILLON said near *Combretaceae. Davidia* position doubtful.

109. ALANGIACEAE

Old World trees and shrubs; Asia, Australia, Afr.; gen. 1.

Lvs. alt., simple, exstipulate. Fls. in axillary cymes, small, perfect; pedicels articulated. Calyx truncate or with 4-10 teeth. Petals 4-10, mostly linear, sometimes connate at base. St. as many as petals, or 2-4 times as many, villous inside, disk present. Ovary inferior, 1-2 celled; ovule 1, pendulous. Fr. a drupe, crowned by sepals and disk. Seed 1, seed coats 2, endosperm present. — HUTCHINSON near *Cornaceae.*

WANGERIN, Pflreich. 1910: Differs from *Cornaceae* in ovule and in pollen development. ENDLICHER and BAILLON said near *Combretaceae* and *Rhizophoraceae;* perhaps near *Polyosma* (ovary inferior, berry one-seeded) in *Saxifragaceae.*

110. COMBRETACEAE

Old World trees and shrubs, some climbing; Trop. Asia and Afr., rare in Subtropics; gen. 15.

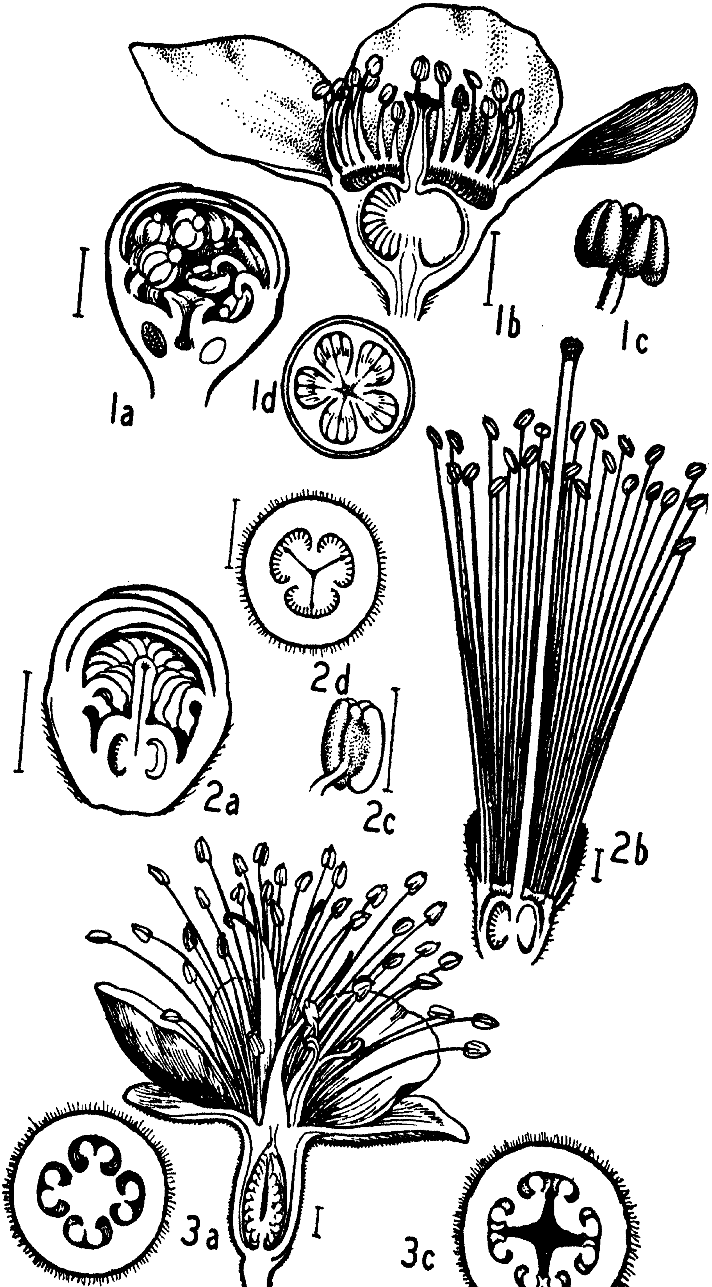
Wood hard, valuable. Lvs. entire, exstipulate. Fls. usually epigynous. Calyx 4-5 lobed, petals small, 4-5 or none. Sts. 4-5, or twice or three times as many. Ovary 1-celled, ovules 2-6, pendulous from apex by slender funicles. Cotyledons folded, endosperm none. — BH 66, TH 221.

111. PUNICACEAE (Pomegranate Family)

Small trees or shrubs, often spiny, Medit. to Himalayas; gen. 1; pomegranate of ancient cultivation.

Lvs. partly opposite, no oil cells. Calyx colored, tubular, adnate to ovary, 5-7 lobed. Petals 5-7, crumpled in bud. Sts. many, from calyx tube. Ovary inferior, in 2 super-imposed series; usually 3 cells in lower, plac. axile; 5-7 in upper part plac. parietal;

Myrtaceae. — 1, *Leptospermum incanum;* a: bud, connective tipped by conspicuous gland; b: fl., sts. numerous, short, connate at base, ovary inferior; c: connective gland less prominent than in bud; d: ovary, plac. axile. — 2, *Callistemon lanceolatus;* a: bud, filaments bent; b: fl., filaments very long, style single; c: anther with gland; d: ovary upper part, plac. parietal (*i.e.* placentae separate). — 3, *Feijoa Sellowiana;* a: fl., styles separate; b: ovary lower part, plac. axile; c: ovary upper part, plac. parietal.


1a
1b
1c
1d
2a
2b
2c
2d
3a
3b
3c

each cell with several ovules; style and stigma 1. Fr. a berry; pulpy mass formed from fleshy outer seed coats. Cotyledons folded, endosperm present. — Very near *Myrtaceae.* — TH 218.

112. MYRTACEAE (Myrtle Family)

Aromatic shrubs and trees, mostly in Trop. Am. and Australia; in Eu., *Myrtus* only; *Metrosideros* in Australia, S. Afr., Polynesia; gen. 75; *Eucalyptus,* wood hard, rapid growth, principal forest trees of Australia; *Eugenia* (clove), *Pimenta* (allspice), *Psidium* (guava).

Intraxylar phloem. Lvs. usually opp., leathery, gland dotted, fragrant; stipules small or none. Calyx lobes 4-5, petals 4-5; in Eucalyptus petals form a cap, separating when fl. opens. Sts. very numerous, often brightly colored, long, often in fascicles opp. petals. Ovary inferior, 1-many celled; plac. mostly axile. Fr. a berry or drupe in American sps., a capsule in Australian sps.; usually a few ovules or only one develops into seed. Embryo straight or curved, endosperm little or none.

BH 67, TH 222. — ANDREWS, 1913: *Myrteae,* early type in American Tropics; early forms were trees, later forms shrubs. Early types had fleshy fruits; later came capsular fruit, a response to less fertile habitats. Australia separated from Asia in Upper Cretaceous, at first with large inland sea. In Cretaceous slight land relief, climate mild and moist. Today high mountains, great deserts, and large continents. — ATCHISON, 1946: In *Leptospermoideae,* six genera, inc. *Eucalyptus* and *Callistemon,* $n = 11$; this subfamily mostly in Tasmania; in *Myrtoideae* four genera: *Myrtus, Eugenia, Feijoa, Psidium,* $2n = 14$ to 88; this subfamily world-wide. Cytological variation suggests American origin for family.

113. MELASTOMACEAE

Mostly small trees or shrubs, a few herbs; mostly trop. Am., also Trop. As. and Afr., not in Australia; gen. 175.

H. A. GLEASON, 1948: "Leaves opp. or rarely whorled, usually with 3-9 strong longitudinal veins, exstipulate, without oil-cells. Fls. regular, 3-6-merous, usually 5-merous, perigynous. Hypanthium well developed, free from the ovary or adnate to it, bearing the petals, sepals, and stamens at its summit. Sepals, petals, and stamens free and distinct. Stamens normally twice as many as the petals, inflexed in bud; anthers opening mostly by terminal pores, the connective often prolonged basally or variously appendaged. Ovary 2-6 celled, inferior or superior; plac. axile; ovules usually many; style and stigma one. Fr. a capsule enclosed in the calyx or a berry surmounted by the calyx; seeds small, no endosperm. — Possibly from same ancestral stock as *Lythraceae.*" — BH 68, TH 223.

114. ONAGRACEAE (Evening Primrose Family)

Herbs, a few annuals, rarely shrubs, often aquatics; Temp. and Subtrop., mostly Am.; gen. 40.

Lvs. simple, opp. or alt., exstipulate. Calyx adnate to ovary, 4-lobed, rarely 2-3 lobed; petals 4, 3, or 0, mostly with claw. Sts. as many as petals or twice as many. Ovary 2-4 celled, inferior, rarely half inferior; floral tube often extending beyond ovary; style 1, stigmas 1-4; ovules many, on axile placentae. Fr. usually a capsule, endosperm none. — In *Clarkia, Oenothera* and others large blade develops below cotyledons. — BH 70, TH 224 (*Oenotheraceae*).

Trapoideae. (BH, TH, HUTCHINSON sub *Onagraceae; Hydrocaryaceae* RAIMANN 1893; or *Trapaceae*). Floating annual; Eu., Asia, and Afr.; *Trapa,* sp. 1. Embryo dvt. differs from *Onagraceae* proper. Rosette of lvs. at surface of water, supported by inflated leaf stalks. Submerged stem bears pair of finely branched roots. Fls. slightly perigynous, 4-parted, except ovary has 2 carpels, crowned by corona-like disk. Only 1 carpel develops, resulting in woody, 1-celled, 1-seeded nut (waternut), edible. Cotyledons very unequal.

115. HALORAGACEAE

Herbs, mostly aquatic, of diverse appearance, cosmopolitan; gen. 8.

Fls. small, perfect or unisexual, in axils of lvs. or bracts; sepals 4, petals 4 or none, stamens 4 + 4, outer 4 opp. petals, or only 4. Ovary inferior, 1-4 celled, each cell with 1 ovule. Fr. nutlike, often crowned by calyx. Seed 1, anatropous, pendulous, endosperm abundant. — BH 64, TH 225.

Gunneroideae (*Gunneraceae* of ENDLICHER, of WETTSTEIN). Terrestrial herbs; lvs. very large; carpels 2, ovary 1-celled, only 1 ovule.

SCHINDLER, 1905: *Haloragaceae* near *Onagraceae;* not near *Hippuris* or *Callitris.*

Family? *Hippuridaceae* (BH, HUTCHINSON sub *Haloragaceae,* TH 225a). *Hippuris,* aquatic perennial, widely distributed throughout world; sp. 1. With creeping rhizome, lvs. in whorls, usually linear. Fls. small, axillary, perfect or polygamous. Calyx entire, petals none. St. 1, anther large, carpel 1, ovary inferior, style slender, ovule 1, suspended. Fr. nut-like, 1-celled, 1-seeded.

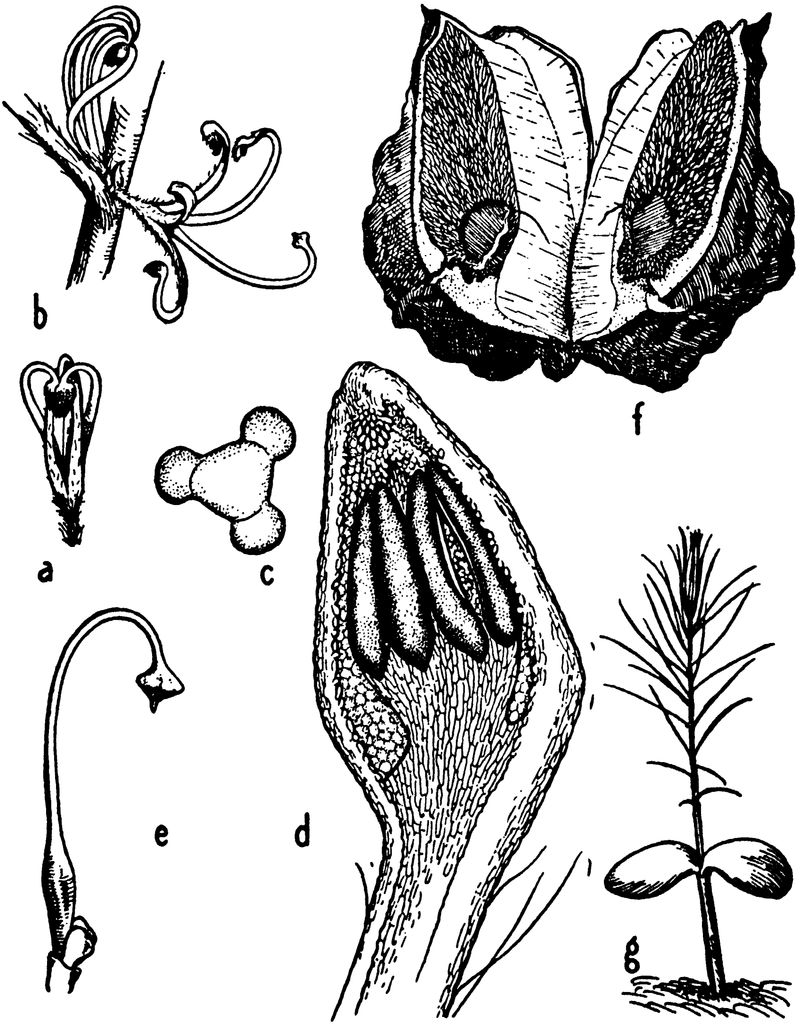
SCHINDLER, 1904: *Hippuridaceae* should be family, perhaps near *Santalaceae.*—JUEL, 1911: embryogeny.—WARMING, 1912, placed *Hippuris* next to *Cornaceae,* under *Cornales.*

116. CYNOMORIACEAE

Cynomorium, root-parasitic herb of saline regions of Medit. and w. Asia; sp. 1.

Sap violet-colored. Stem succulent, with many scale-like lvs., at summit dense flower cluster. Fl. unisexual or bisexual, perianth segments 1-5. Ste. fl.: st. 1, vestigial ovary. Carp. fl.: carpel 1, ovary inferior, ovule 1. Endosperm present.

BH and HUTCHINSON sub *Balanophoraceae*, TH 226. — Fam. ENGLER, 1897.



Proteaceae. — *Hakea gibbosa;* a: bud; b: fl. with four long sepals, anthers at tips, single carpel with large stigma; c: pollen grain tetrad; d: enlarged tip of sepal with two anthers (four anther-cells); e: carpel with glands; f: woody fr. with winged seeds; g: seedling.

PROTEALES

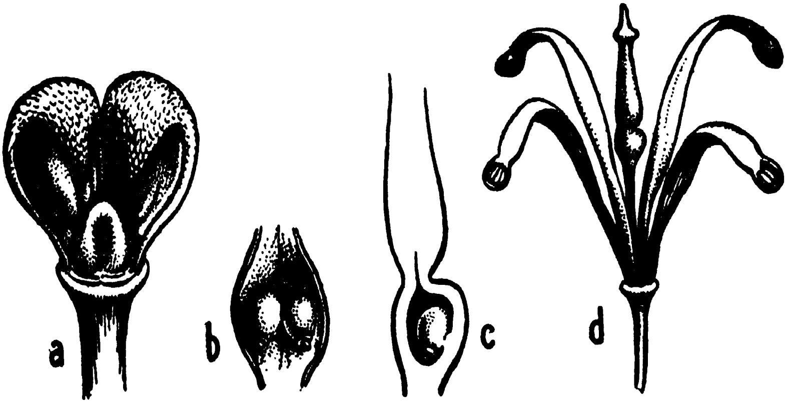
Single family.

Chromosomes:
Proteaceae — *Grevillea* 8, 10; *Protea* 12.

117. PROTEACEAE

Shrubs and trees, very rarely herbs, mainly in drier regions of Australia and S. Afr., few in Tropics and in Temp. S. Am., gen. 50.

Lvs. mostly alt., exstipulate. Fls. mostly perfect, rarely unisexual. Perianth single, colored, 4-parted, usually tubular in bud, split when open. Sts. 4, filaments adnate to perianth lobes. Carpel 1, ovule 1, or many. Fr. a follicle, nut or drupe. Seeds often winged, seed-coats 2, embryo straight, endosperm none. — *Bellendena*, sts. free (*cf. Trema, Ulmaceae*); *Banksia* and *Protea* fls. have abundant nectar. — BH 144, TH 66.



Proteaceae. — *Grevillea* sp. (from Payer); a: bud; b, c: ovary; d: fl.

Persoonioideae. Fl. single in axils of bracts, fr. 1-seeded. *Leucadendron, Protea.*

Grevilleioideae. Fls. usually two in axils of bracts, fr. usually many-seeded. *Banksia, Hakea, Grevillea.*

Fletcher, 1909: *Persoonia* polycotyledony. — Brough, 1933: *Grevillea* life history.

SANTALALES

Perianth single; sts. opp. perianth parts. Ovary inferior or half inferior. Carpel usually with 1 ovule, in endosperm.

Chromosomes:
Loranthaceae — *Viscum* 10, 11.
Santalaceae — *Santalum* 10; *Thesium* 10, 12; *Buckleya* 15.

118. OLACACEAE

Trees and shrubs, some timber trees; Tropics and Subtropics; gen. 26.

Lvs. alt., exstipulate. Fls. small, calyx small, petals 3-6, free or united, disk present. Sts. few or many, carpels 2-5, stigma 1. Ovary superior, at base 2-5 celled, ovule 1 in each cell. Fr. sometimes enclosed by enlarged calyx. Endosperm abundant.

BH 45, TH 67. — SLEUMER, Pflfam. 1935: *Olacaceae* should come before *Santalaceae;* differences in having calyx and seed coats; often not parasitic; entire order may not be in right place.

Octoknema (*Octoknématacées* VAN TIEGHEM, 1905, TH sub *Olacaceae*). Trees; Trop. W. Africa. Lvs. alt., with stellate hairs, exstipulate. Fls. unisexual in axillary racemes. Perianth single, connate below, 5-parted. Ste. fls. sts. 5, free; with rudimentary ovary. Carp. fl. ovary inferior, 3-celled, at first, becoming 1-celled; ovules 3, suspended, connected with base by threadlike placenta. Fr. drupaceous, seed 1, embryo small, seed coat 1; endosperm oily. — MILBRAED, Pflfam. 1935: Near *Olacaceae,* but with rudimentary petals.

Chingithamnus (*Chingithamnaceae,* HANDEL-MAZZETTI, fam. nov. 1932). sp. Kwangsi, China. Shrub 5 m., lvs. opp., coriaceous, exstipulate. Infl. to 5 fls. Calyx with hypanthium, sepals 5, thick; petals 5, sts. 5. Ovary superior, short, 1-celled, placenta basal; style thick. Ovules 4, erect, anatropous; integ. 2. Fr. a capsule, embryo straight. — Characters suggest *Olacaceae.*

119. OPILIACEAE

Trees and shrubs, some climbing; Trop. Asia and Afr., some in Brazil; gen. 7.

Lvs. alt., exstipulate. Calyx minute, petals 4-5, sometimes united. Sts. opp. petals, free or united to base of petals, disk-glands alt. with sts. Ovary superior or half-inferior, ovule 1, endosperm abundant. Fr. a drupe.

TH 68. — Gagnepain, 1910: Separates *Aptandraceae, Schoepfiaceae, Erythropalaceae* as families. — Sleumer, Pflfam. 1935: Calyx, usually not distinct, sometimes 4-parted, as in *Olacaceae.*

120. SANTALACEAE (Sandalwood Family)

Half-parasitic green herbs, shrubs or small trees, some on branches on trees, other root parasites; sandalwood and others not parasitic. Widely distributed in Tropics and Temp.; gen. 25.

Lvs. entire, sometimes reduced to scales, exstipulate. Perianth single, green or colored, often fleshy, adnate to ovary, perianth lobes 3-6. Sts. 3-6, opp. perianth lobes. Ovary inferior or half inferior; 1 celled; ovules 1-3, from basal placenta. Fr. indehiscent, 1-seeded. Seed coat none, endosperm abundant. — *Santalum* ovary nearly superior.

BH 149, TH 69. — Pilger, Pflfam. 1935; *Santalaceae* nearest *Olacaceae;* second nearest is *Loranthaceae.*

Grubbia (*Grubbiaceae,* family Endlicher, 1838, TH 70). Shrubs; S. Africa. Lvs. opp., linear, pubescence stellate. — Fls. perfect, very small, in axillary clusters. Perianth single, 4-parted. Sts. 4 + 4, with hairy disk. Ovary inferior, at first 2-celled; plac. parietal or central, ovules 2, pendulous. Seed 1, embryo linear, endosperm fleshy. — Harms, Pflfam. 1935: Near *Santalaceae* but ovules differ; Decaisne, also Van Tieghem say near *Bruniaceae.*

121. MYZODENDRACEAE

Half-parasitic subshrubs on *Nothofagus* in s. S. Am.; gen. 1.

Lvs. alt., small or reduced. Dioec., fls. minute. Ste. fls. perianth none, sts. 2-4, around small disk. Carp. fls. calyx adnate to ovary, free at top, ovary 1-celled, style thick, stigma 3; ovules 3, pendulous from apex of thick central placenta. Endosperm fleshy.

TH 68. — Skottsberg, Pflfam. 1935: *Myzodendron* nearest to *Arjona* in *Santalaceae.*

122. LORANTHACEAE (Mistletoe Family)

Parasitic or half-parasitic shrubs, mostly tropical; gen. 20; ***Viscum album*** (European mistletoe).

Lvs. usually opp., entire, often leathery and long persistent. Fls. mostly regular, receptacle cup-shaped, perianth double, the two whorls alike, each 2-3 parted, free or united. Ovary inferior, 1-celled, with large, central placenta, which merges with ovules. Embryo in fleshy endosperm, cotyledons often 3-6.—*Nuytsia,* in separate fam., VAN TIEGHEM, 1896.

BH 148, TH 67.—DANSER, 1931: Believes *Elytranthe* group most primitive. Most *Loranthoideae* depend on birds for pollination, also for fruit distribution; when birds prefer flowers and fruits of more advanced forms, primitive types are likely to die out.

123. BALANOPHORACEAE

Root parasites, leafless, without chlorophyll, mostly in Tropics of both hemispheres; gen. 14.

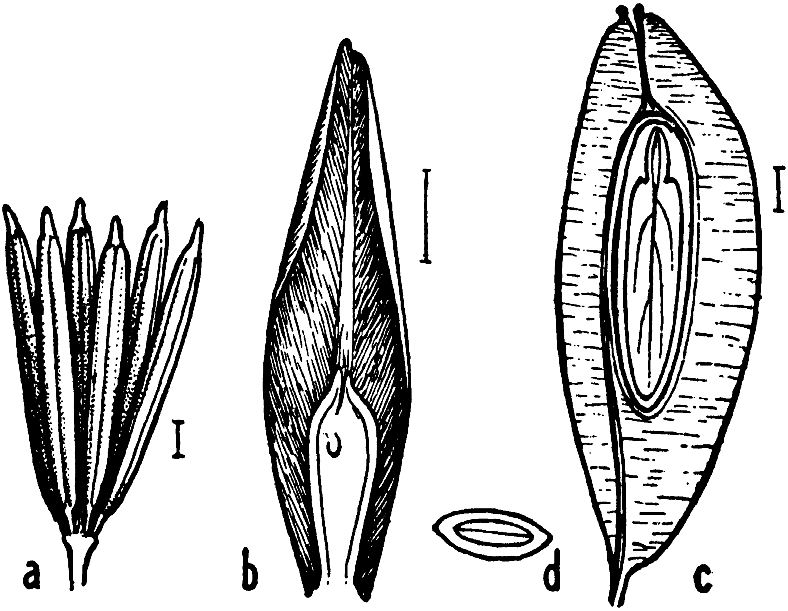
Monoec. or dioec. Ste. fl. perianth single, tubular, 4-5 lobed; sts. 4-5, opp. perianth parts. Carp. fl. mostly no perianth, carpels 1, 2 or 3, ovary 1-celled. Fr. a nut. Embryo small, undifferentiated, endosperm oily.

BH 150, TH 73.—HARMS, Pflfam. 1935: Family lacks unity; position uncertain, perhaps near *Santalaceae.*

URTICALES

Lvs. stipulate, fls. many, small, infl. cymose. Calyx usually 4-parted. Chalazogamy occasional.

Chromosomes:
Eucommiaceae — *Eucommia* 17.
Moraceae — *Dorstenia* 6, 7, 8; *Humulus* 8, 10; *Cannabis* 10; *Broussonetia, Ficus* 13; *Artocarpus, Cecropia, Cudrania, Morus* 14.
Ulmaceae — *Celtis, Ulmus, Zelkova* 7.
Urticaceae — *Boehmeria, Parietaria* 7, 13; *Urtica* 11, 12, 13.



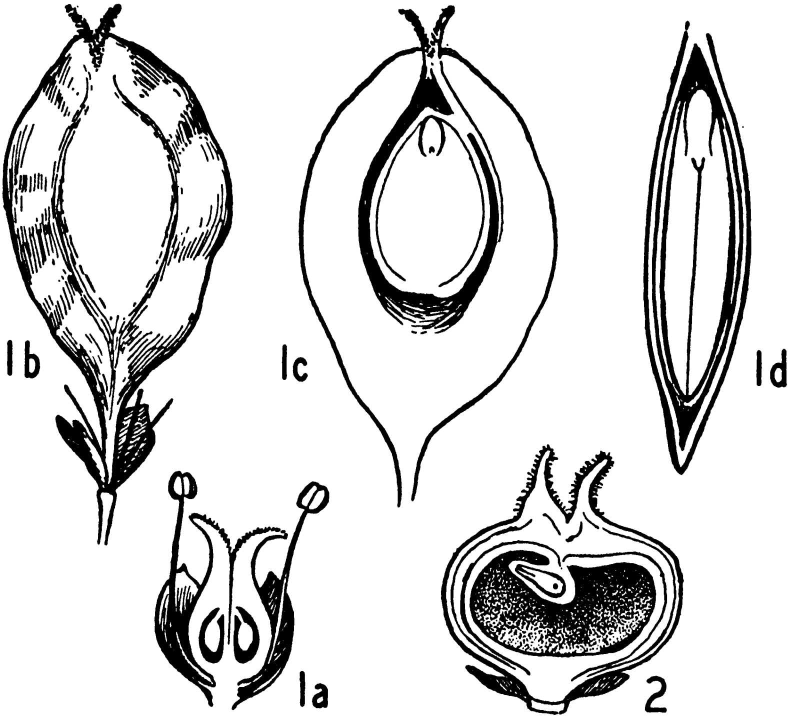
Eucommiaceae. — *Eucommia ulmoides,* no perianth; a: ste. fl., six sts., filaments short, connective projecting; b: carp. fl. with bract; c: winged fruit, single seed, embryo with veined cotyledons; d: seed cross sec.

124. EUCOMMIACEAE

Eucommia; tree, C. China; sp. 1.

Sap containing rubber, lvs. alt., elm-like, exstipulate. Dioec., perianth none. Ste. fls. in bracted clusters; sts. 6 to 10, connective projecting. Carp. fls. single, in axil of bract; carpels 2, 1 generally aborting. Fr. 1-seeded, slightly winged; embryo long, cotyledons narrow, flat, endosperm abundant.

TH 123a.—Harms, Pflfam. 1930: Single genus perhaps better in *Urticales,* on account of external appearance, form of stigma and winged fr.—Tippo, 1940: Anatomically much nearer to *Ulmaceae* than to *Hamamelidaceae:* vessels with simple perforations, wood often ring-porous, latex present; fl. and fruit structure support anatomy.



Ulmaceae.—1, *Ulmus parvifolia;* a: fl. sec. showing two (of five) sts. opp. calyx lobes, two carpels, each with one suspended ovule, usually only one carpel developing; b: winged fr. with remains of fl.; c: sec. fr., embryo filling seed; d: seed, cotyledons, radicle and plumule, seed coats two.—2, *Zelkova serrata;* young fr., style very short, stigmas turned to one side, ovule suspended in cavity.

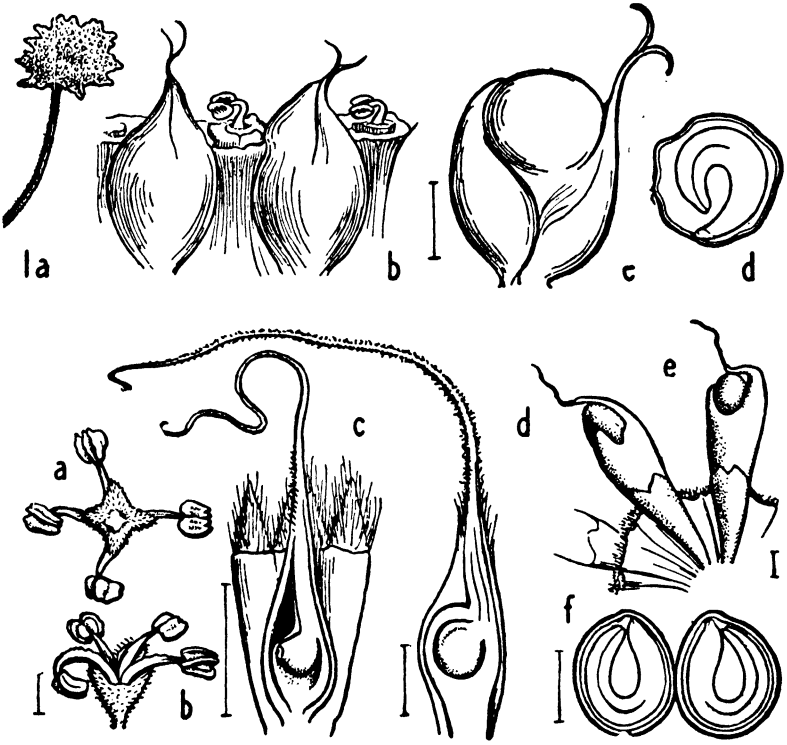
125. ULMACEAE (Elm Family)

Trees and shrubs, N. Temp. Zone, some tropical; gen. 14; *Ulmus* (elm), *Celtis* (hackberry), *Zelkova.*

Vessel perforations simple or vestigial scalariform. Lvs. alt., often asymmetrical, stipulate.—Fls. small, perfect or monoec.

Perianth single, usually 4 or 5 parted, sts. opp. sepals. Ovary 1-celled, ovule 1, pendulous, stigmas usually 2. Fr. often winged; endosperm none.

Barbeya (*Barbeyaceae*, Rendle, fam. nov.; of Hutchinson); tree, Arabia and Trop. Africa; 1 sp. Lvs. opp., exstipulate. Dioec. St. fls. calyx 3-4 parted, petals none, sts. 6-9, connective apiculate. Carp. fls. sepals 3-4, in fr. enlarged and submembranous. Ovary 1-celled, ovule 1, suspended, anatropous. Fr. dry, indehiscent. Endosperm none.



Moraceae. — 1, *Dorstenia contrajerva;* a: fl. cluster; b: enlarged sec., ste. fls., each of one st., carp. fls. sunk in disk; c: sec. fr., two carpels and stigmas, single seed; d: sec. seed. — 2, *Broussonetia papyrifera;* a: ste. fl. under side, four-lobed calyx, sts. opp.; b: same, side view; c: bud carp. fl., calyx lobes, sunken ovary; d: same, later; e: fr. cluster, seed at top; f: sec. seed.

TH 63. — Bechtel, 1921: Family not a primitive group. *Ulmus,* the primitive genus, shows evidence of suppression of first whorl and of 1 perianth whorl; zygomorphy conspicuous; in lvs. no palmate venation, but in perianths of some sp.; sts. fused to perianth; ancestry of *Ulmus* was probably polycarpellate, polyovulate, and entomophilous.

126. MORACEAE (Mulberry Family)

Trees and shrubs with milky sap, some climbing; *Dorstenia* herbaceous; mainly Tropics; gen. 60; *Ficus* (fig), *Morus* (mulberry, silkworm tree), *Artocarpus* (breadfruit tree).

Lvs. mostly alt., with stipules. — Fls. small; perfect, monoec. or dioec.; often in heads; in *Ficus* on or in hollow disk. Perianth single, calyx lobes 4, sts. 4, opp. sepals. Carpels 2, usually only 1 developing, styles 2, filiform. Ovule 1, usually pendulous. Embryo often curved, seed with or without endosperm. — Genus *Fatoua* is nearest *Ulmaceae*.

Cannaboideae (*Cannabinaceae* of HUTCHINSON, *Cannabaceae* of WETTSTEIN). *Cannabis* (hemp), *Humulus* (hops). Herbaceous; dioec. Ste. fl.: calyx 5-parted, sts. 5, filaments short. Carp. fl.: calyx a cupule surrounding ovary, stigmas 2, long. Fruit an akene, embryo curved. — TH 64.

127. URTICACEAE (Nettle Family)

Mostly herbaceous; Trop., few Temp.; gen. 40; *Boehmeria* (ramie), fibre plant of India and China.

Lvs. stipulate, often with stinging hairs. Infl. cymose. Monoec. or dioec. Fls. small, wind-pollinated. Perianth single, green, mostly 4-parted, in ste. fl. parts free, in carp. fl. often united. Sts. mostly 4, uncoiling elastically. Carp. fls. with calyx often enlarged in fr.; staminodes sometimes present, scale-like; ovary 1-celled, with long stigmatic hairs. Seed basal, seed coats 2; endosperm usually oily.

TH 65. — HOLM, 1937: Slime cells confirm possible affinity with *Tiliaceae; Laportea* slime-cells and latex ducts suggest *Malvaceae* and *Euphorbiaceae*. — BERNBECK, 1932: Varied inflorescences in *Urticaceae* and *Moraceae* lead up to *Dorstenia* and *Ficus*.

BALANOPSIDALES

128. BALANOPSIDACEAE

Trees and shrubs, New Caledonia and Trop. Australia; gen. 1.

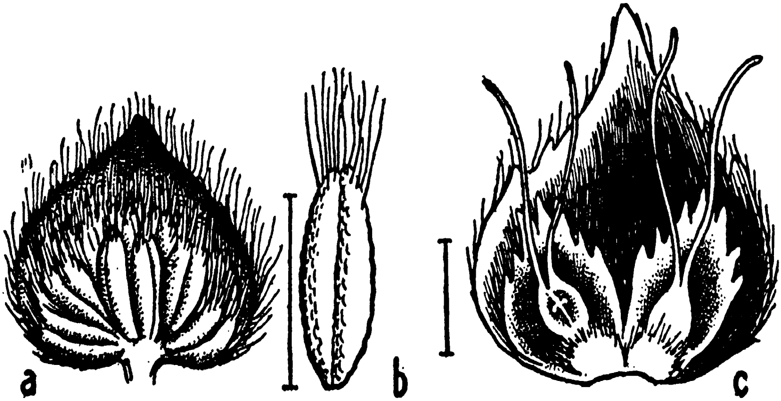
Perforations plate scalariform. Lvs. alt. or in whorls. Dioec. Ste. fls. in cluster, with single bract. Carp. fls. single, enclosed by many bracts; ovary 2-celled; styles 2, each divided into 2 branches Fr. a drupe; seed with endosperm.

BH 152, TH 58.—BH note resemblances to *Daphniphyllum*.

FAGALES

Trees and shrubs. Lvs. alt., stipulate. Fls. monoecious, wind-pollinated. Ovary inferior, plac. axile, each cell with 1-2 suspended ovules; styles separate. Chalazogamy. No endosperm.

Chromosomes:
Betulaceae — *Alnus, Betula, Corylus* 7; *Carpinus, Ostrya* 8.
Fagaceae — *Castanea, Fagus, Quercus* 12.



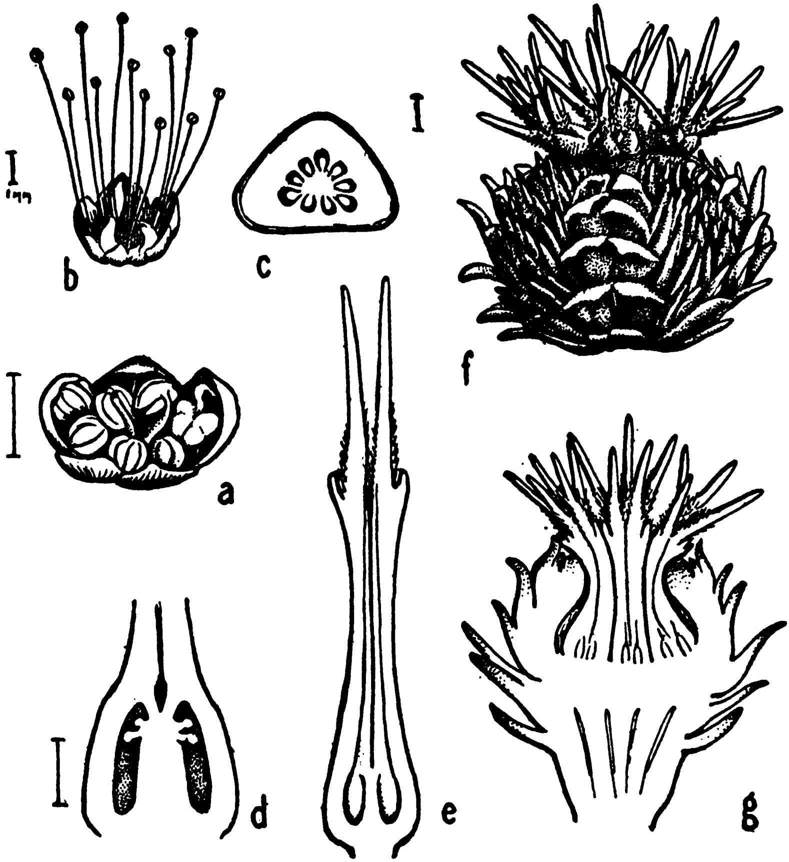
Betulaceae. — *Carpinus Betulus,* no perianth; a: hairy bract and ste. cluster; b: anther two-forked with terminal hairs; c: bract and two bractlets with carp. fls., ovary of two carpels, each with one ovule, stigmas long, linear.

129. FAGACEAE (Beech Family)

Large trees, a few shrubs, in Temp. and Subtrop. N. Hemisphere; *Nothofagus* in s. S. America, New Zealand and Australia; gen. 5; *Quercus* (oak), *Fagus* (beech), *Castanea* (chestnut), *Pasania.*

Lvs. alt., stipules deciduous. Wind-pollinated except *Castanea.* Monoec. Ste. fls. in catkins, sts. few — 40, rudimentary ovary often present. Carp. fl. 1, in involucre of scales; ovary 3-6 cells, styles 3. Fr. a nut, seed usually 1, seed coats 2, endosperm none.

TH 62. — Berridge, 1914: Chalazogamy prevails in *Fagaceae, Betulaceae* and *Juglandaceae; Fagaceae* resemble *Rosaceae* in epidermis, hypoderm, stomata, hairs, both ordinary and glandular, in origin of cork, structure of pericycle, character of wood; less near to *Hamamelidaceae* or to *Anacardiaceae.* — Tippo, 1938: Chalazogamy seems to have lost much of its phylogenetic significance; *Fagales* probably from *Hamamelidaceae.*

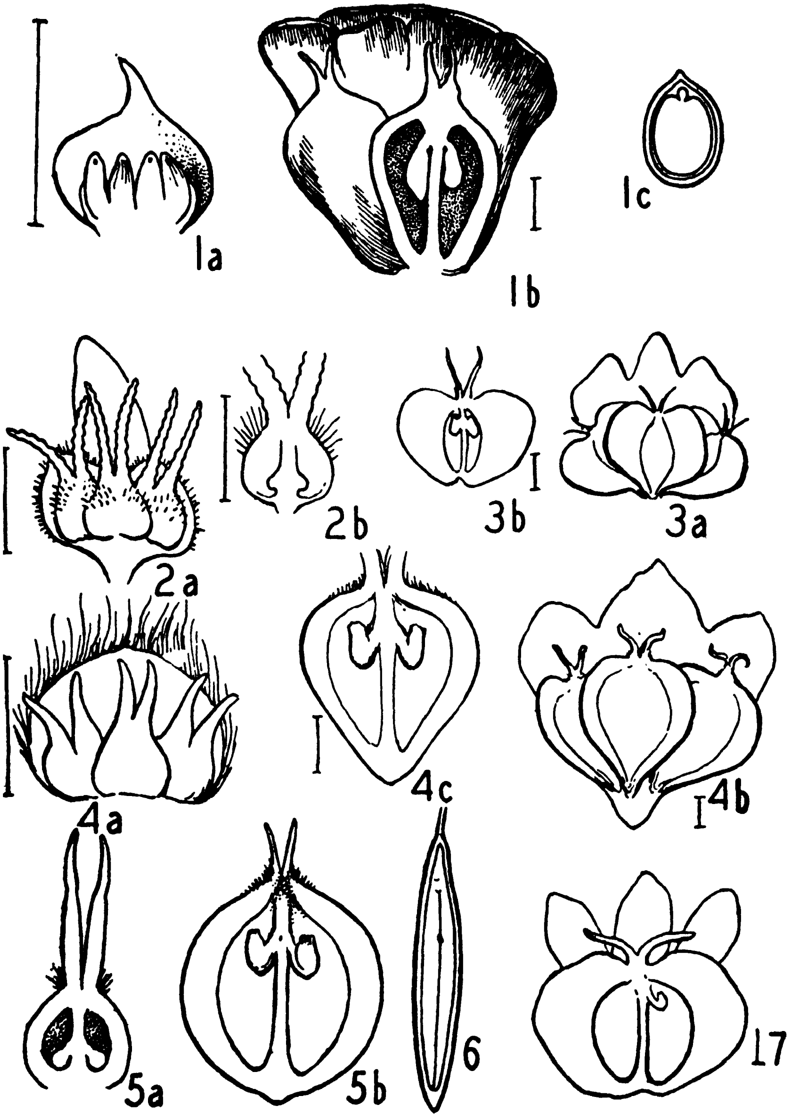


Fagaceae. — *Castanea mollisima;* a: bud ste. fl.; b: same, adult, calyx six-parted, filaments long; c: section ovary, nine young ovules; d: same longit. sec., axile plac.; e: same adult fl., ovules suspended, one in each carpel, ovary inferior, perianth scales, styles flat, hairy below; f: three carp. fls., in scaly involucre, styles projecting, stigmas small; g: sec. of fls.

130. BETULACEAE (Birch Family)

Trees and shrubs; N. Temp. and Arctic Zones; Alnus along Andes to Argentina, also South to Bengal; gen. 6.

Wood type more primitive than in *Fagaceae.* Lvs. alt., straight-veined, with deciduous stipules. Monoec.; fls. in reduced cymose



Betulaceae.—1, *Alnus hirsuta;* a: bud carp. fl., bract, parts of two bractlets, each with two carpels nearly separate; b: later, carpels fused and woody bract fused with ovary, ovules axile, suspended; c: seed with flat embryo, seed coat one.—2, *Betula papyrifera;* a: three-lobed bract with carp. fls., no bractlets; b: sec. young ovary.—3, *B. glandulosa;* a: bract with 3 carp. fls.; b: single ovary, two stigmas and ovules.—4, *B. grossa;* a: hairy bract with three carp. fls.; b: later stage; c: sec. ovary, ovules axile, anatropous.— 5, *B. Ermani;* a: young ovary, plac. axile, at base; b: later, ovules raised, anatropous.—6, *B. pubescens;* embryo filling seed.—7, *B. davurica;* 3 lobed bract and middle fl.

panicles. Individual ste. fls. 1-4 (5) sts., filaments short. Carp. fls. in clusters or catkins; ovary 2-celled, styles 2; each cell with 1 pendulous, anatropous ovule. Fr. 1-seeded; cotyledons oily, seed coat 1, endosperm none.

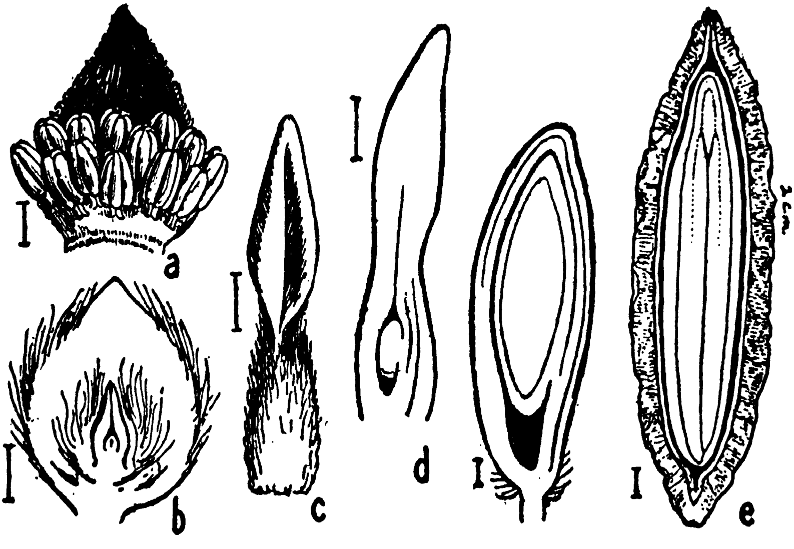
TH 61. — WINKLER, Pflreich. 1904: *Betulaceae* differ from *Fagaceae* in 2-celled ovary, single seed coat, ste. fls. from bract, sts. often divided, usual absence of involucre. — ABBE, 1935, 1938: The so-called floret is a reduced infl. of a few crowded fls. The bicarpellary ovaries owe their diverse orientation to derivation from tricarpellary ovary. Sts. often trimerous groundplan. Perigon only in carp. fls. of *Coryleae*, only in ste. fls. of *Betuleae*. Ancestral individual fls. probably had 6-parted perigon, 6 sts., ovary inferior, 3 carpels, axile placentation.

LEITNERIALES

131. LEITNERIACEAE (Corkwood Family)

American shrub; S. Mo. to Fla. and Texas; sp. 1.

Wood very light, soft. Lvs. alt., entire, exstipulate. — Dioec., fls. in erect catkins; conspicuous bract below each fl. Ste. fls. in 3 fl. groups, perianth none, each fl. 1-4 sts. Carp. fl. subtended by usually 4 bracts, connate at base, 1-celled, with long style. Fr. a drupe. Ovule 1, endosperm thin.



Leitneriaceae.—*Leitneria floridana,* no perianth; a: ste. fl., bract with twelve sts., filaments short; b: bract with carp. bud, tomentose; ovary one-celled, ovule one; c: ovary with large style, lateral groove; d: sec. ovary, ovule amphitropous; e: fruit a drupe, embryo nearly filling seed.

BH 155, TH 59.—Abbe and Earle, 1940: Anatomy of carp. fl. suggests formerly several carpels and several ovules; perigon of 3 to 8 small sepals in carp. fl., none in ste. fl.; vascular evidence of 3 fls. in axil of primary bract; perhaps near *Hamamelidaceae* or *Geraniales.*

CASUARINALES

Chromosomes:
Casuarinaceae — *Casuarina* 9, 12.

132. CASUARINACEAE

Shrubs and much branched trees, with aspect of *Ephedra* or *Equisetum;* chiefly Australasia and East Indies; gen. 1.

Wood heavy, anatomy highly specialized; branches jointed; stomata in deep furrows. Lvs. scale-like, united at base, in alternating whorls; leaf node unilacunar. Monoec., some dioec.; wind pollination. Stc. fls. in spikes, usually with 2+2 bracts, st. 1. Carp. fls. in heads, carpels 2, with usually 2+1 bracts. Chalazogamy. Ovary at first 2-, later 1-celled, seed 1. Fr. cluster cone-like, each fr. winged, enclosed by 2 spreading bracts. Endosperm in ovule, not in seed. Embryo straight, cotyledons large, seed coats 2.

BH 158, TH 51. — Cordemoy, 1923: Fruits of *C. equisetifolia* carried by ocean currents. — Moseley, M. F. Jr.: *Casuarina* not primitive, floral morphology suggests derivation from *Hamamelidaceae*-like ancestors. (Bot. Gaz. 110:231-280. 1948).

MALVALES

Lvs. mostly stipulate. Fls. regular. Sepals and petals usually 5. Sts. usually many, in bundles. Carpels 2-many, plac. axile. Seed with endosperm, embryo often curved, seed-coats 2.

Chromosomes:

Malvaceae — *Althaea, Malva, Pavonia* 7; *Abutilon* 7, 8; *Hibiscus* 7-20; *Gossypium* 12, 13. — LONGLEY, 1933: *Gossypium,* n = 13 (mostly Asiatic); n = 25 (American spp.), except that 2 Amer. spp. and 1 Australian belong with Asiatic spp.; distribution of n = 13 species suggests that ancestral American spp. had low chromosome number.

Sterculiaceae — *Theobroma* 8?, *Sterculia* 8, 10.

Tiliaceae — *Corchorus* 7, *Grewia* 9, *Tilia* 41.

133. SCYTOPETALACEAE

Trees; Trop. W. Afr.; gen. 4.

Lvs. leathery, exstipulate. Calyx cup-like, entire or toothed, petals 3-7. Sts. many, in several whorls, sometimes connate at base, anthers 2-celled. Ovary 3-6 celled, plac. axile; ovules pendulous, 2-several in each cell. Fruit woody or drupe-like. Embryo linear, endosperm abundant. — TH 179. Fam. ENGLER 1897, (*Rhaptopetalaceae* PIERRE).

134. CHLAENACEAE

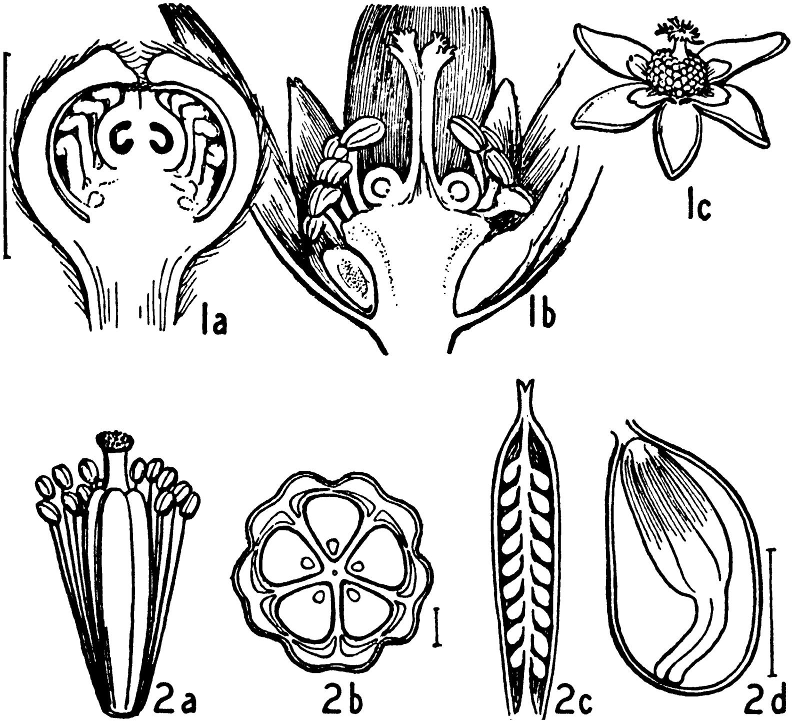
Shrubs and trees, some climbers; Madagascar; gen. 7.

Lvs. alt., entire, stipules falling early. Sepals 3, petals 5-6, contorted. Circle of small staminodes surrounds 10 or more sts. Ovary 3-celled, stigma 3-lobed, 2 or more ovules in each cell. Embryo straight, in endosperm. — BH 30, TH 172.

135. ELAEOCARPACEAE

Trees and shrubs, mostly in Tropics, not in Afr.; gen. 8.

No mucilaginous cells. Lvs. simple, stipulate. Sepals 4-5, separate or united; petals 4-5, often fringed. Sts. many in groups opp. petals, also 4-5 separate; anthers opening by apical pores. Ovary 2-many celled, plac. axile, ovules many; rarely 1-celled with parietal plac.; style 1. Seed sometimes with aril; endosperm little. — TH 171.



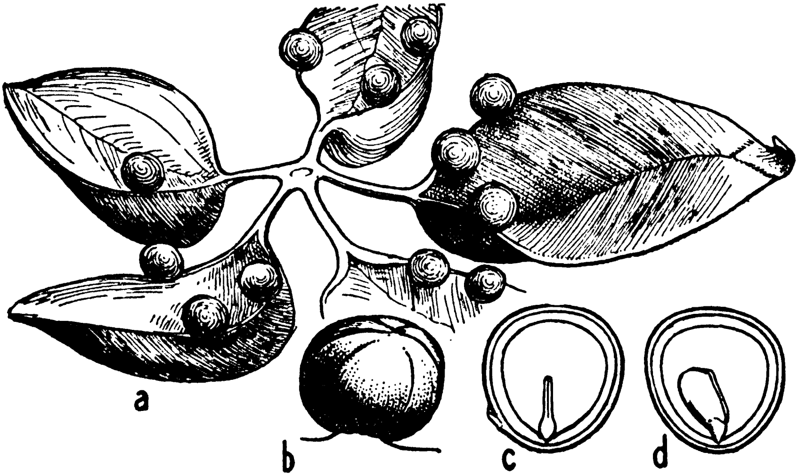
Tiliaceae. — 1, *Grewia parviflora;* a: bud, sepals thick, petals thin, sts. and pistil only slightly raised; b: fl., sts. and pistil on androgynophore, sts. separate, each carpel one ovule; c: fr., sepals large, petals small, ciliate at base, sts. numerous, stigma fringed.—2, *Corchorus olitorius;* a: sts. and carpels; b: ovary, five carpels, plac. axile; c: ovary, two inches long, many seeds, pendulous; d: seed, embryo in endosperm, cotyledons small, leaf-like.

136. TILIACEAE (Linden Family)

Trees and shrubs, a few herbs; widely distributed, mostly in warm climates; gen. 40; *Corchorus* (jute), fiber plants, extensively grown in India.

Mucilage cells in pith and cortex. Lvs. alt., stipules falling early. Fls. cymose. Sepals 5, deciduous, sometimes connate. Petals 5, sometimes none. Sts. usually many, free or shortly connate, or in 5 or 10 bundles; anthers 2-celled. Ovary 2-many-celled, style 1, plac. axile, ovules 1-several in each cell. Fr. a drupe or berry. Endosperm usually present, seed coats 2.

BH 33, TH 174. — RUFF, 1930: Approves GOEBEL and HIRMER interpretation of phylogeny, that grouped sts. in *Hypericaceae, Cistaceae, Tiliaceae,* etc. do not represent few sts. divided, but rather originally many sts., five sectors of axis developed in advance; *Dilleniaceae, Cistaceae,* and *Malvaceae* are primitive; *Parietales* and *Malvales* closely related. — KUKACHKA & REES, 1943: Shrubby *Tiliaceae* probably more primitive than trees; fl. structure and anatomy apparently correlated; *Elaeocarpaceae;* a distinct family, more primitive than *Tiliaceae.*



Sterculiaceae. — *Firmiana simplex;* a: fr. of follicles, ovules at first on central column, carpels separating before maturity, seeds near base; b, c, d: single seed, embryo in abundant endosperm, cotyledons broad.

137. STERCULIACEAE

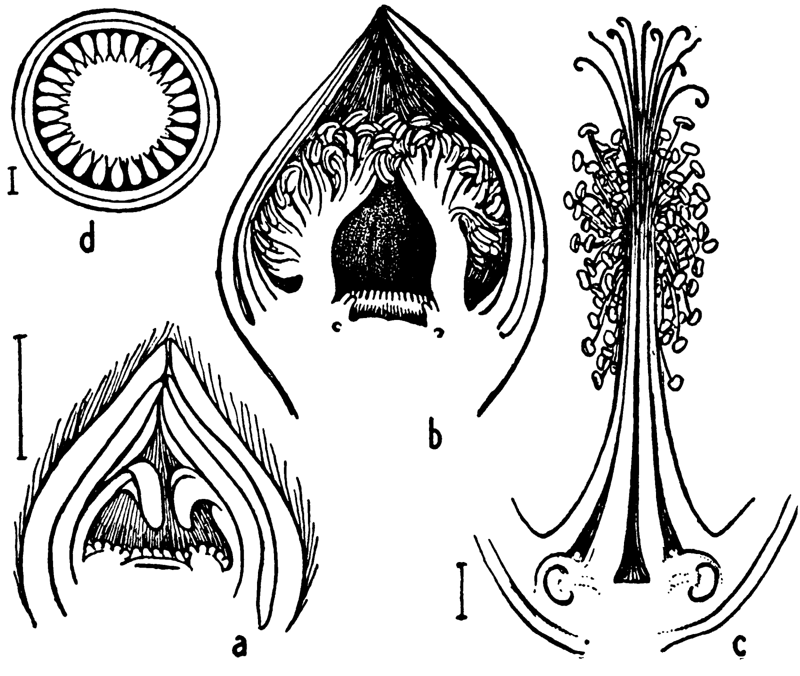
Trees and shrubs; Tropics and Subtropics; gen. 50; *Theobroma* (cacao or chocolate tree), *Cola.*

Wood soft, vessel perforations simple. Lvs. usually alt., simple or palmately compound. Sepals 3-5, partly connate; petals 5 or none, free or adnate to base of staminal tube, petals twisted-imbricate. Androgynophore often supports sts. and ovary. Sts. 5-10, more or less united, outer sts. often sterile; anthers 2-celled. Carpels 2-5, rarely 10-12, more or less united, plac. axile. Ovules usually 2 in each cell. Fr. mostly a capsule, often separating into cocci. — *Sterculia* and *Cola* unisexual, apetalous. — BH 32, TH 178.

138. BOMBACACEAE

Trees, often with swollen trunks, widely distr. in Tropics; gen. 20; *Ceiba* (kapok or silk cotton tree), *Ochroma* (balsa wood), *Durio* (durian, Malayan fruit), *Adansonia* (inc. baobab, African tree, wood soft, trunk swollen).

Lvs. simple or palmately compound, pubescence stellate or scurfy. Fls. large, calyx cup-like or 5-lobed, often subtended by epicalyx. Petals 5, sometimes none. Sts. many, filaments free or lower part tubular; anthers 1-celled, sometimes 2-celled. Ovary 2-5-celled, plac. axile, ovules 2 or more in each cell. Cotyledons flat or folded, endosperm little or none. — TH 177.



Malvaceae. — *Althaea rosea;* a: bud two mm., sts. and carpels nearly alike; b: bud four mm., ste. branches conspicuous (*cf. Ricinus*); c: fl., ste. column, styles stigmatic on inner side, one ovule per carpel (*cf. Phytolacca*); d: sec. young ovary of numerous carpels, later separating.

139. MALVACEAE (Mallow Family)

Mostly herbs and shrubs, a few trees; cosmopolitan; gen. 50; *Gossypium* (cotton, world's principal fiber crop), *Hibiscus* (okra and rose-of-Sharon), *Althaea* (marshmallow).

Mucilage cells present. Lvs. mostly palmately veined, stipulate, with stellate hairs. Fls. often large, epicalyx often present. Sepals 3-5, often connate. Petals 5, twisted in bud, adnate at base to staminal column. Sts. many, monadelphous, staminal column divided at apex; anthers 1-celled; pollen grains large, spiny. Ovary 2-5-many-celled; plac. axile, ovules 1-several, anatropous. Fr. usually dry, carpels separating; seed coats 2; cotyledons often folded, usually some endosperm. — In *Malope* Tribe carpels many, in more or less vertical rows.

BH 31, TH 175. — Webber, 1934: *Malvaceae* wood anatomy fairly advanced in phylogenetic scale.

EUPHORBIALES

Fls. unisexual, perianth single or none. Ovary of 3 carpels, plac. axile, each cell with 1 or 2 suspended ovules.

Chromosomes:

Buxaceae — *Buxus, Sarcococca* 7 or 14.

Euphorbiaceae — *Acalypha, Phyllanthus* 7; *Euphorbia* 6, 7, 8, 9, 10; *Croton* 8, *Daphniphyllum* 8, *Hevea, Manihot, Sapium* 9; *Ricinus* 10, *Jatropha* 11.

140. DICHAPETALACEAE

Small trees and shrubs, some climbing; Tropics, especially Afr.; gen. 3, sap poisonous.

Lvs. simple with stipules. Fls. small, sepals 5, sometimes connate. Petals 5, mostly 2-lobed or 2-parted, often united with sts. to form a tube. Sts. 5, with nectar glands opp. petals. Ovary 2-3 celled, superior to inferior, ovules 2 in each cell, pendulous from apex. Fr. a drupe. Embryo large, straight, endosperm none.

BH 44 (as *Chailletiaceae*), TH 146. — ENGLER and KRAUSE, Pflfam. 1931: Very natural family; BAILLON under *Euphorbiaceae;* probably near *Phyllanthus.*

141. EUPHORBIACEAE (Spurge Family)

Woody plants and herbs; chiefly tropical, few in Temp.; gen. 300; *Ricinus* (castor bean), *Aleurites* (tung oil), *Manihot* (cassava), *Hevea* (Brazilian rubber tree), *Chrozophora* (girasol).

Often with milky sap. Lvs. alt., usually with stipules. Monoec. or dioec. Fls. regular, of varied structure, often much reduced. Perianth mostly single; *Andrachne, Chrozophora, Poranthera* and others have sepals and petals. Sts. as many as sepals, twice as many, or numerous, in *Euphorbia* 1. Disk often present. Carpels 3, rarely 2-4 or many, each with 2-1 ovules. Fr. usually a capsule, separating into 3 parts (cocci). Seed coats 2, seed usually with caruncle above micropyle, endosperm abundant. — In *Euphorbia* no perianth; ste. and carp. fls. form special infl. called cyathium; ste. fl. with only 1 st. *Ricinus* sts. branching; *Jatropha* petals united; *Hura* carpels many; in *Mercurialis* two.

Four subfamilies, two in Australia, represented by *Poranthera* and *Ricinocarpus*, with narrow cotyledons.

Phyllanthoideae, latex none, each carpel with 2 ovules.

Crotonoideae, each carpel with 1 ovule, latex present or absent.

BH 151, TH 147. — Bucynon, 1922: Cotyledons of *Mercurialis annua* resemble those of *Brachychiton acerifolium* (*Sterculiaceae*). — Michaelis, 1924, and Pax, 1925: Fls. suggest that apetalous forms were derived from ancestors with sepals and petals. — Haber, 1925: In *Euphorbia* petaloid appendages are closely associated with gland; articulation between pedicel and filament represents position of abortive perianth. "Ovary" of cyathium is pistillate fl.; pistil is composed of three 1-ovule carpels; disk represents abortive perianth. — Pax and Hoffman, Pflreich. 1910-1928, parts; Pflfam. 1931: *Euphorbiaceae* are reduced forms, probably from *Geraniales* and *Malvales*, less near to *Sapindales*. — Jansonius, 1929: *Daphniphyllum* has scalariform perforations; in *Euphorbiaceae* mostly simple; in *Phyllantheae*, *Aporosa*, etc., partly or all scalariform. — Moyer, 1934: Species relations in *Euphorbia* indicated by electrophoresis of latex. — Schoute, 1937: On aestivation and interpretation of cyathium; defends views of Eichler, Roeper, against Haber, Schmidt, Flueck, Troll. — Croizat, 1941: In *Euphorbiaceae* and in *Sterculiaceae* bud scale is reduced leaf, over-developed in stipular part, under-developed at blade.—*See* Fam. 22.

Daphniphyllum, Asiatic shrubs; Himalaya to Java and Japan; gen. 1. — Lvs. entire, exstipulate. Fls. unisexual, in racemes. Perianth single or none, 3-6 parts. St. fls. 6-12 sts. Carp. fl. 4-2 celled, each with 2 ovules. Fr. a 1-seeded drupe. Embryo small, raphe ventral, seed with endosperm. — BH, TH, and Rehder, sub *Euphorbiaceae*; *Daphniphyllaceae*, Mueller-Arg., fam. Prodromus, 1869, of Diels, of Rosenthal, Pflreich, 1919 and Pflfam. 1931: Near *Euphorbiaceae* on account of ovary and ovule; separate because of small, apical embryo and ventral raphe; opposed to Hallier's view, that *Daphniphyllum* is near *Hamamelidaceae*.—*See* Fam. 128.

142. BUXACEAE (Boxwood Family)

Mostly shrubs or trees, evergreen, widely distributed; gen. 6.

Lvs. opp. or alt., exstipulate. Mostly monoec. or dioec.; fls. small, sepals usually 4, petals none. Sts. 4 or 6, ovary 3-celled, ovules 1-2 in each cell, pendulous. Capsule loculicidal. Seed black, sometimes with caruncle, with endosperm. Seed coats 2.

TH 149. — In *Buxaceae* raphe dorsal, in *Euphorbiaceae* ventral; Tippo says *Buxaceae* perhaps near *Hamamelidaceae*.

RUTALES

Lvs. usually with oil-glands. Fls. usually with disk inside the sts. Ovule attachment usually different from that in *Sapindales* or *Celastrales*.

Chromosomes:
Rutaceae — all genera 9, in *Citrus* apomixis.
Simarubaceae — *Quassia* 9?

143. BURSERACEAE

Mostly large trees, some shrubs; chiefly in Trop. Am., some in Afr. and Asia; gen. 15; *Boswellia* (frankincense), *Commiphora* (myrrh), *Canarium* (pilinut).

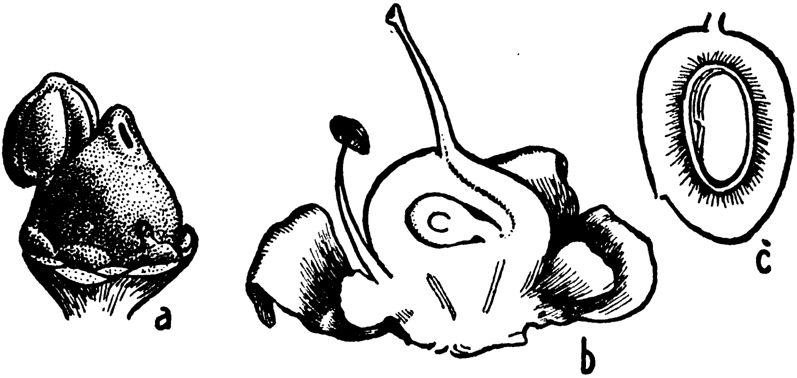
Resin or oil cells present. Lvs. alt., pinnate, exstipulate. Fls. perfect or unisexual, small. Sepals and petals 5, 4 or 3 parts. Disk present, sts. in 1 or 2 whorls, free. Ovary 2-5 celled, plac. axile. Ovules usually 2 in each cell. Fr. usually a drupe. Cotyledons often contorted, no endosperm.

BH 42, TH 139. — ENGLER, Pflfam. 1931: *Burseraceae* not near *Anacardiaceae,* because of the important difference in ovule position. — LAM, 1932, 1938: Phylogeny of *Burseraceae;* centers are America (*Protieae*), Africa (*Bursereae*) and Asia to Australia-Polynesia (*Canarieae*); Eastward migration probable. — HEIMSCH, 1941: From wood anatomy of 1000 spp. in 37 families, incl. *Burseraceae, Meliaceae, Sapindaceae, Rutaceae, Simarubaceae, Anacardiaceae,* concludes these are better classified by WETTSTEIN, by HUTCHINSON, esp. by HALLIER, than by ENGLER. — WEBBER, 1941: Wood anatomy shows *Burseraceae* and *Anacardiaceae* are more primitive than *Rutaceae* and *Simarubaceae; Burseraceae* wood diffuse porous, growth rings frequently absent; *Meliaceae* most specialized.

144. ANACARDIACEAE (Cashew Family)

Trees and shrubs, mainly tropical, some in Temp. Am., Temp. As., and S. Eu.; gen. 60; *Mangifera* (mango), *Anacardium* (cashew nut), *Rhus* (sumac and poison ivy), *Pistacia* (pistachio).

Resin ducts in bark; lvs. odd pinnate or simple, exstipulate. Often polygamo-dioec. Fls. in panicles; usually small, regular, numerous. Sepals 3-7, petals 3-7, or none, rarely connate and adnate to receptacle. Sts. usually twice number of petals, rarely equal or many, often glands between sts. Disk cuplike, sometimes forming conspicuous stalk on which ovary is raised, as in *Anacardium.* Ovary superior to inferior, styles 1-3, often widely separated; ovule 1, pendulous from apex or erect from basal funiculus. Fr. a drupe. Seed with hard testa; embryo curved, cotyledons fleshy, endosperm little or none. In *Rhus,* chalazogamy. — In *Pistacia* and others, funiculus swollen; family characters suggest *Burseraceae,* also *Connaraceae,* and *Juglandaceae.*



Anacardiaceae. — *Mangifera indica* (from Payer); a: bud, perianth removed, small staminodes, single stamen fertile, young ovary; b: fl., single st., ovary of single carpel with single ovule, thick funiculus; c: seed with hard seed coat, no endosperm.

BH 53, TH 153. — Guillaumin, 1909. — Copeland, 1940: In *Toxicodendron* n = 15; pollen grain 3-grooved, 2-nucleate; carpels 3, two of them greatly reduced; ovule 1, anatropous, integ. 2, nucellus massive; obturator-like growth from base of funiculus. Fr. a small drupe. *Juglandaceae* not derived from *Anacardiaceae,* but collateral relationship possible.

145. JULIANIACEAE

Trees and shrubs; Mexico to Peru; gen. 2.

Resin abundant, lvs. alt., pinnate, exstipulate. — Dioec. Fls. small, green. Ste. fls. in racemes or panicles, calyx 3-9 lobed, petals none. Sts. as many as calyx lobes. Carp. fls. 3 or 4 in involucre, perianth none. Ovary superior, 1-celled, style 3-parted, ovule 1, half anatropous, partly concealed by growth of funicle; endosperm none. — Resembles *Anacardiaceae* in lvs., presence of resin, solitary exalbuminous seed, form of embryo, and wood anatomy.

TH 60b. — Fam., HEMSLEY, 1908. — FRITSCH, 1908: Close anatomical resemblance to *Anacardiaceae*, not to *Juglandaceae;* not either to *Cupuliferae,* advocated by HEMSLEY. The creation of a new order (: family) calls for very careful scrutiny of evidence from every point of view. — KERSHAW, 1909: Outgrowth at base of ovule (obturator) common to *Juglans* and *Juliania;* vascular supply similar in *Juglans, Juliania* and *Myrica.* — WETTSTEIN: *Julianiaceae* (first) and *Juglandaceae* in same order.

146. CORIARIACEAE

Shrubs, widely distr. warm Temp.; Himalayas, e. Asia, Medit., New Zealand, S. Am.; gen. 1.

Branches angular; lvs. simple, opp. or whorled, exstipulate. Fls. small, greenish, sepals 5; petals 5, keeled inside. Sts. 5+5, those opp. petals adnate to keel, filaments short. Carpels 5-10, free, ovules 1 in each, pendulous. Fr. separating into nutlets. Endosperm little. — WETTSTEIN says position doubtful. — BH 54, TH 151.

147. CNEORACEAE

Small shrubs; Medit. and Canaries; gen. 1.

Lvs. narrow, leathery. Fls. with peduncle adnate to petiole. Receptacle elongated, grooved. Sepals 3-4, small, persistent. Petals 3-4, elongated. Sts. 3-4. Ovary 3-4 celled, cells 1-2 ovules, pendulous; style 3-4 lobed. Fr. 1-4 drupes; seed and embryo curved, with endosperm.

TH 136. — ENGLER, family, 1890, Pflfam. 1931: Carpels somewhat like *Zygophyllaceae;* distinguished by single stc. whorl, no stipules, presence of oil-cells; somewhat distinct from other *Geraniales.*

148. SIMARUBACEAE

Trees and shrubs; mostly in Tropics; gen. 30; *Ailanthus* (tree of Heaven), *Picrasma.*

Bark bitter, no oil glands; lvs. pinnate, usually alt., exstipulate. Fls. small, usually dioecious or polygamous. Calyx lobes 3-7, petals 3-7, rarely connate or absent. Disk present, sts. equal or double number of petals, sts. sometimes with scale at base. Ovary usually 2-5 lobed, or carpels separate, styles 2-5, plac. axile, ovule often 1. Fr. sometimes winged. Cotyledons thick, endosperm little or none. — BH 40, TH 138. — ENGLER, Pflfam. 1931.

149. RUTACEAE (Rue Family)

Shrubs and trees, rarely herbs; Temp. and Subtrop., esp. S. Afr. and Australia; gen. 100; *Citrus* (orange, lemon, lime, grapefruit).

Lvs. simple or compound, with pellucid glands, strongly aromatic, exstipulate. Sepals 5-4, free or connate, petals 5-4, mostly free. Sts. same number or twice as many, rarely numerous, disk usually present; obdiplostemony common. Ovary lobed, somewhat raised, 5-4 celled, ovules often 2 in each; carpels usually slightly united, forming a deeply lobed structure. Seed with or without endosperm. — *Amyris* and *Feronia,* plac. parietal.

BH 39, TH 137. — Engler, Pflfam. 1931: With many-celled oil glands; near several families, along one line: *Rutaceae — Zygophyllaceae;* along another: *Rutaceae — Simarubaceae — Burseraceae — Meliaceae.* — Nakamura, 1941: Color reactions of *Citrus* barks agree with Tanaka's classification of spp.

150. MELIACEAE (Mahogany Family)

Trees and shrubs, Tropics and Subtropics; gen. 50; wood hard, often reddish and scented, valuable for furniture.

No resin or oil glands. Lvs. mostly pinnate, exstipulate, not glandular-punctate. Sepals 4-5, often small, petals 4-5, sometimes connate. Sts. 8-10, filaments usually connate, disk present. Ovary mostly 2-5 celled, usually 2 ovules in each cell, style and stigma 1, stigma often capitate. Seeds sometimes winged. — *Cedrela, Toona,* sts. free.

BH 43, TH 140. — Harms, Pflfam. 1931: Hutchinson makes *Meliaceae* separate order, but sts. sometimes connate also in *Rutaceae, Simarubaceae,* and *Burseraceae.*

JUGLANDALES

Trees and shrubs. Fls. unisexual, wind-pollinated. Perianth single or absent. Ste. fls. in catkins. Carpels 2-5, with single ovule. Seed coat 1, endosperm none.

Chromosomes:
Juglandaceae — Carya, Pterocarya 16; *Juglans* 16, 17.
Myricaceae — Comptonia, Myrica 8.

151. RHOIPTELEACEAE

Rhoiptelea; tree in s. w. China; sp. 1.

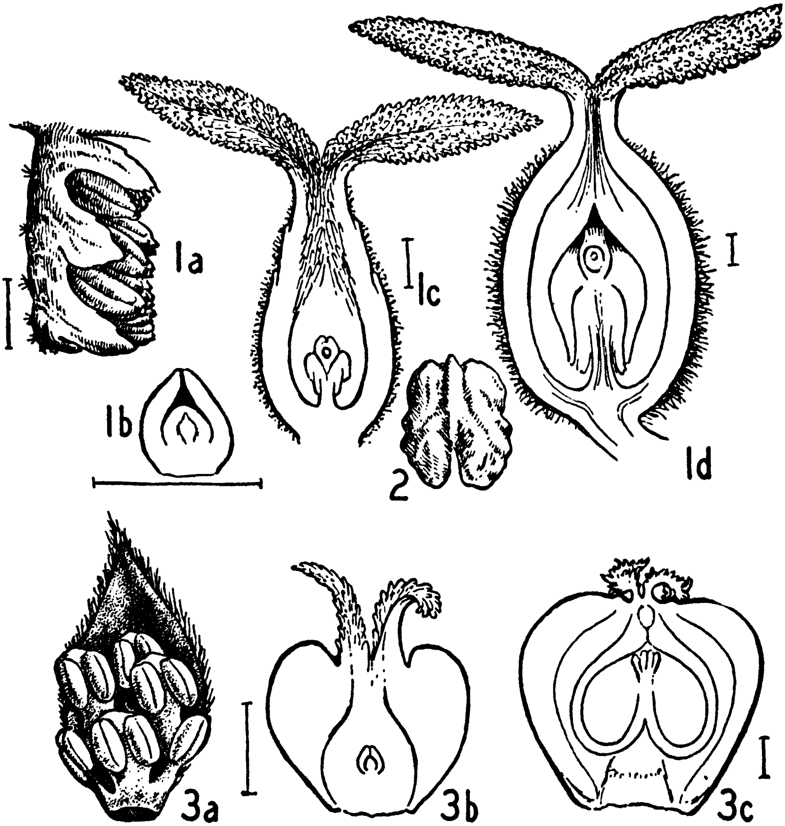
Lvs. pinnate, glandular, stipulate. Fls. in panicles of catkins, in clusters of 3. Fl. bracts 2+2. Sts. 6. Carpels 2, ovule 1, half-anatropous. Nutlet 2-winged; embryo straight, cotyledons thick; endosperm none.

Handel-Mazzetti, 1932, fam. nov.: Fr. resembles *Ulmus;* wood like that of *Acer;* no disk or nectaries. — Tang, 1932: *Rhoiptelea* wood like *Aphananthe* (*Ulmaceae*). — Withner, 1941: Anatomy resembles that of *Juglandaceae,* esp. *Alfaroa:* thin-walled fiber tracheids, gelatinous fibers, heterogeneous I rays, alt. intervascular pitting, long vessel elements, scalariform plates. Fl. suggests Manning's prejuglandaceous form; not very near *Julianiaceae* or *Anacardiaceae.* Manning, letter 1947: *Rhoipteleaceae,* evidently related to *Juglandaceae,* has features close to *Alfaroa* and pre-*Juglandaceae,* each bract of each catkin subtending 3 flowers, the lateral flowers pistillate, the central flower perfect with a bract, 2 bracteoles, 4 sepals, 6 stamens, a 2-carpellate, 2-celled pistil, ovary superior, the solitary ovule at the middle of the partition in the 1 fertile cell.

152. JUGLANDACEAE (Walnut Family)

Large trees, *Juglans* (walnut), *Carya* (hickory) and others, in warmer parts of N. Temp., some in Tropics and some in Temp. S. Am.; gen. 7.

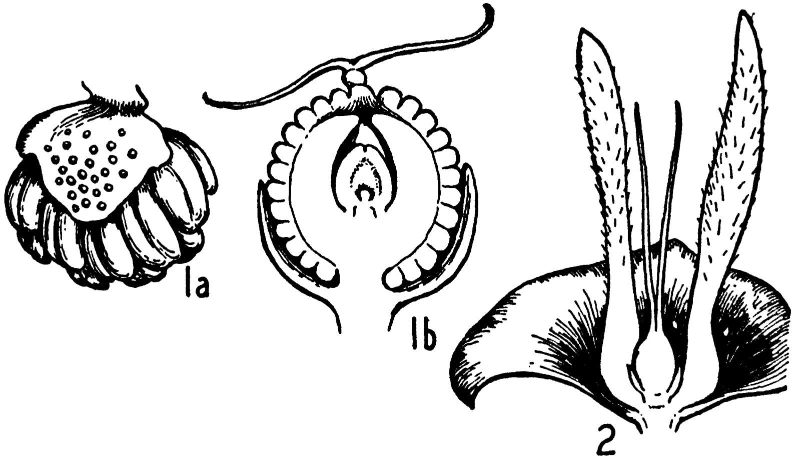
Wood resinous, durable. Lvs. large, pinnate, aromatic, exstipulate. Monoec. or rarely dioec. — Ste. fls. in catkins, filaments short; usually numerous; pistil rudiments occasionally present. Carpel. fls. of 2 carpels, adnate to bract and 2 bracteoles, in catkins or small clusters; calyx 4-lobed. Ovary inferior, 1-celled above, 2-4-celled below; ovule 1, erect at the top of primary partial partition, modified axile. Chalazogamy. Fruit a nutlet with 2 or 3 wings, or a nut enclosed in a fleshy husk, formed of ripened bract, bracteoles, and sepals. Seed 2 or 4 lobed; cotyledons rich in oil, U-shaped, 4-lobed, fleshy-corrugated or foliaceous, the main partition dividing each cotyledon, hence each cell of ovary contains the halves of 2 different cotyledons. Endosperm none. Seed coat



Juglandaceae.—1, *Juglans Sieboldiana;* a: bracts and many sts., connective projecting; b: one celled ovary, half mm., no stigma; c: stigmas plumose, ovule raised on placenta; d: later stage.—2, *J. regia* seed.—3, *Platycarya strobilacea;* a: ste. fls. in bract; b: carp. fl. bud, bracts later become wings; c: ovary with raised seed (*cf. Anacardium*).

apparently 1. Peltate glands characteristic. — In *Carya, Platycarya*, and *Rhamphocarya* no perianth.

BH 156, TH 60. — KRIBBS, 1927: From wood anatomy concludes there are only four distinct genera: *Carya, Platycarya, Juglans* and *Engelhardtia. Pterocarya* belongs with *Juglans; Alfaroa* with *Oreamunoa* section of *Engelhardtia.* — MANNING, 1936, 1940, and letter 1947: Floral envelope consists of 1 bract, 2 bracteoles, 4 sepals, in some genera aborted or modified; petals lacking. Terminal androgynous panicle of catkins most primitive, solitary catkin or short spike the most advanced type of inflorescence. *Alfaroa* and *Engelhardtia* most primitive, *Juglans, Pterocarya, Rhamphocarya* somewhat advanced, *Carya* and *Platycarya* most advanced. Ancestors (pre-*Juglandaceae*) had terminal panicles with perfect (*bisexual*) flowers, subtended by broad bract and two bracteoles, 4 (5 or 6?) sepals, numerous stamens, 3 carpels and sub-globose stigmas; fr. probably loculicidal capsule with many axile ovules. Features of *Juglandaceae* and *Rhoipteleaceae* are similar in many ways to *Anacardiaceae*, but wood anatomy, according to HEIMSCH, 1942, indicates *Juglandaceae* is more primitive than *Anacardiaceae*, and different, hence probably not derived from *Anacardiaceae.* — HEIMSCH and WETMORE, 1939: Wood anatomy in striking accord with MANNING.



Myricaceae. — 1, *Myrica pennsylvanica;* a: bract and pendent group of sts.; b. carp. fls., one-celled ovary with waxy granules, style with two branches, ovule single, erect, basal. —2, *Comptonia peregrina,* carp. fl. with broad outer bracts, two long bracts and eight narrow scales.

153. MYRICACEAE (Bayberry Family)

Shrubs, widely distr., esp. in colder n. Temp., also in S. Afr.; gen. 2; *Myrica, Comptonia.*

Lvs. resin-dotted, fragrant. — Monoec. or dioec. Ste. fls. in spikes, bract below each fl., perianth none, sts. 2-16. Ovary 1-celled, carpels 2, stigmas 2; ovule 1, erect, orthotropous. Seed coat 1; endosperm of single-cell layer, oily.

BH 157, TH 57. — WARMING, also RENDLE: *Myricaceae* and *Juglandaceae* in same order. — KERSHAW, 1909: Ovules of *Myrica* resemble those of *Juglandaceae*.

SAPINDALES

Lvs. without oil glands. Fls. usually with disk outside of sts. Calyx and corolla mostly 5-parted.

Chromosomes:

Aceraceae — *Acer* 13

Sabiaceae — *Sabia* 12.

Sapindaceae — *Cardiospermum* 11; *Litchi* 14, 15; *Koelreuteria* 15; *Aesculus* 20.

Staphyleaceae — *Staphylea* 13.

RENDLE used as orders *Rutales, Sapindales, Celastrales.* According to HEIMSCH, 1941, wood anatomy brings *Sapindaceae, Aceraceae, Connaraceae* together with *Rutaceae, Meliaceae, Anacardiaceae;* but *Linaceae, Polygalaceae, Vochysiaceae, Malpighiaceae* have different type of wood.

154. SAPINDACEAE (Soapberry Family)

Trees and shrubs, some herbs (*Cardiospermum,* balloon vine); widely distributed, mostly tropical; gen. 125; *Litchi* (Chinese fruit).

Lvs. mostly alt., compound. Fls. usually obliquely zygomorphic. Sepals and petals 3, 4, or 5; petals sometimes none, often scales or hairs inside petals. Disk extra-staminal, conspicuous. Sts. 8 or 10, in 2 whorls, more or less connate. Ovary mostly 3-celled, deeply 3-lobed, 1 ovule in each cell. Fr. various, endosperm none, aril frequent, cotyledons often twisted.

BH 51, TH 165. — RADLKOFER, Pflreich. 1931-1934.

Aesculus (*Hippocastanaceae,* TH 164; BH and HUTCHINSON sub *Sapindaceae.* Mostly trees, a few shrubs; N. and C. Am., Balkans, Temp. Asia; gen. 2; *Aesculus* (horsechestnut and buckeye). — Lvs. opp., palmately compound. Fls. large. Sts. 5-9, filaments long. Ovary of 3 cells, not lobed, 2 ovules in each. Fr. a 1-3 celled capsule, leathery, often prickly. Cotyledons large, fused.

155. BRETSCHNEIDERACEAE

Bretschneidera, tree; mts. of Yunnan; sp. 1.

Lvs. odd pinnate. Fls. large, rose color. Calyx open campanulate, 5-parted. Petals 5, unequal, perigynous. Sts. 8, filaments slender. Ovary superior, 3-celled, 2 suspended ovules in each cell. Fr. a capsule.

TH sub *Hippocastanaceae.* — Pax, Pflfam. 1936: Differs from *Capparidaceae* in pinnate lvs., in absence of disk and gynophore.

156. STAPHYLEACEAE (Bladdernut Family)

Small trees and shrubs, N. Am. to n. S. Am., Europe, Temp. and Trop. Asia; gen. 5.

Lvs. opp., trifoliolate or pinnate, stipulate. Calyx 5-parted, petals 5, inserted on or below disk. Sts. 5, inserted with petals. Ovary 2-3 celled, ovules many, in 1-2 series on ventral suture. Fr. an inflated capsule. Seeds few, truncate at base, embryo straight, endosperm little.

TH 161. — Foster, 1933: Basic chromosome number 13, same as in *Acer;* polyploid series in each, also secondary pairing of 2 chromosomes in diploid spp.

157. ACERACEAE (Maple Family)

Trees, mostly N. Temp., esp. mtn. regions; in Himalayas to 10,000 ft.; gen. 2; *Acer* (inc. sugar maple), *Dipteronia.*

Lvs. opp., exstipulate, mostly palmately lobed and veined; pinnately-veined in *A. carpinifolium,* pinnate-compound in *A. Negundo* (box elder) and its allies. Fls. mostly andromonoec. or dioec., small, regular. Sepals 4-5, petals 4-5, rarely none. Sts. 3-12, disk usually present. Ovary 2-celled, flattened; 3-carpel fruits occasional; ovules 2 in each cell, attached to axis. Fr. winged; seed usually 1 in each carpel; cotyledons often folded, endosperm none.

TH 163. — Pax, Pflreich. 1902: Nearest *Sapindaceae,* but different form of disk.

158. AKANIACEAE

Akania, tree; n. e. Australia; sp. 1.

Lvs. alt., odd-pinnate, exstipulate. Fls. in panicles. Calyx 5-lobed, petals 5, sts. usually 8, 5 outer opp. calyx lobes, filaments free. No disk. Ovary 3-celled, style 1, stigmas 3, small; ovules 2 or more in each cell. Fr. a loculicidal capsule. Seed covered with long hairs, seed coats 2, endosperm none.

Stapf, 1912, fam. nov. — Harms, Pflfam. 1931: Family isolated; Engler in *Geraniales* because of ovule; Radlkofer and Solereder in *Staphyleaceae;* Hutchinson after *Sapindaceae.*

159. SABIACEAE

Trees and shrubs; Mexico to Brazil, Trop. Asia to China and Japan; gen. 4.

Fls. small, in panicles. Calyx 4-5 parted, petals 4-5. Sts. 4-5, opp. petals, often part sterile; anther with large connective. Ovary 2-3 celled, ovules 1-2 in each cell. Embryo large, cotyledons contorted; endosperm little or none. — BH 52, TH 166.

160. MELIANTHACEAE

African shrubs and small trees; Trop. and Subtrop. Afr.; gen. 3.

Lvs. alt., simple or pinnate; stipules often large, intrapetiolar. Fls. often large, zygomorphic. Calyx 5 parts, unequal; petals 5, clawed, unequal; disk inside calyx. Sts. 4-5-10, free or connate. Carpels 4-5, ovules 1-many. Fr. 1 seed in each cell; seed with endosperm, sometimes with aril. — TH 167.

Greyia (*Greyiaceae,* fam. nov. Hutchinson, 1926; BH sub *Sapindaceae,* Diels sub *Melianthaceae.*) Ornamental shrubs or small trees, S. Afr. Lvs. currant-like. Sepals 5, free, petals 5, perigynous. Staminodes 10, connate below; sts. 10, free. Ovary deeply 5-grooved, style 1, ovules many, plac. parietal. Fr. a capsule, seeds minute, with endosperm.

161. AEXTOXICACEAE

Aextoxicon, **shrub; Chile; sp. 1.**

Lvs. alt., lanceolate, with stellate hairs. Unisexual; fls. small, regular, in racemes. Fl. enclosed in bract, perianth, 4-6 parted. Sts. few, filaments often hairy. Carpels 2, style short, 2-parted; 2-cells, 1 sterile, 2 pendulous ovules in one cell. Drupe 1-seeded. Endosperm ruminate.

Aextoxicaceae, fam. Pax, 1917: Formerly placed in *Monimiaceae,* in *Euphorbiaceae,* and in *Aquifoliaceae.*

162. DIDIEREACEAE

Tall, spiny, cactus-like trees; s. Madagascar; gen. 3.

Wood soft, pith large. Lvs. small, exstipulate. Dioec. Sepals 2, decussate, petaloid, persistent. Petals 2+2, decussate. Ste. fl.: sts. 8-10, on edge of annual disk, filaments woolly. Carp. fls. with staminodes, ovary 3-celled. Ovule 1 in one cell only, erect, anatropous. Style with 3-4 short, broad, irregular stigmas. Fr. triangular, indehiscent. Embryo folded, endosperm none.

TH 78a. — *Didiereae* Radlkofer, 1896, sub *Chenopodiaceae.* — *Didiereaceae,* Post and Kuntze, 1903.

163. MALPIGHIACEAE

Mostly woody climbers, some small trees and shrubs; many in Trop. Am., some in Old World; gen. 60.

Plants mostly covered with "malpighiaceous" hairs: appressed, one-celled, branching. Lvs. usually opp., entire, often with glands at base, petioles jointed, stipulate. Sepals 5, glandular, usually united at base. Petals 5, usually with claws, margin fringed or toothed. Sts. 10, part sterile, outer ones opp. petals, usually connate below; anthers of diverse forms. Carpels 2-3-5 cells, each with 1 ovule, pendulous. Fr. usually separates into 1-seeded parts, nut-like or winged. Embryo usually curved or spiral; endosperm none.

BH 36, TH 141. — NIEDENZU, Pflreich. 1928: Near *Erythroxylaceae*, which have ligules; also near *Zygophyllaceae*; *Malpighiaceae* distinct by ovule position and by hairs; seed twisted as is frequent in *Sapindales*.

164. VOCHYSIACEAE

Trees, often very large, shrubs and woody climbers; Trop. S. Am., 1 sp. in W. Afr.; gen. 6.

Resinous sap. Lvs. usually opp. or whorled, stipules small or none. Fls. oblique-zygomorphic, sepals 5, posterior one often with spur. Petals 1-3, rarely 5; contorted. Sts. only 1 fertile, filaments free, connective projecting. Ovary 1-3 celled, plac. axile, 2-many ovules in each cell. Seed often winged, embryo straight, usually no endosperm. — TH 143.

Trigonia, Mart, 1935. *Trigoniaceae,* TH 142.

American trees and woody climbers; Trop. S. Am.; gen. 3. Sts. 3-12, connate below. Ovary 3-celled, woolly. Seeds covered with long hairs; no endosperm.

165. TREMANDRACEAE

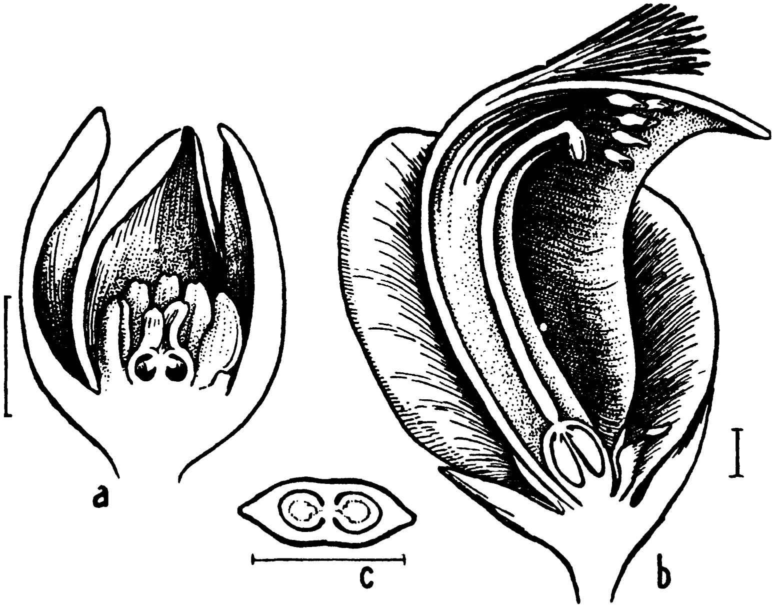
Heath-like shrubs; extra-tropical Australia; gen. 3.

Stem sometimes winged, lvs. small. Sepals 4-5, free, petals 4-5. Sts. twice as many, anthers opening by apical pore. Ovary 2-celled, ovules 1 or 2 in each cell, pendulous. Fr. a compressed capsule. Seed with appendage to chalaza, embryo small, endosperm abundant. — BH 19, TH 144.

166. POLYGALACEAE (Milkwort Family)

Herbs, a few shrubs, climbers and small trees (*Xanthophyllum*); widely distributed over the world, not in New Zealand; gen. 10.

Lvs. entire, exstipulate. Fls. zygomorphic. Sepals persistent, generally 5, free; 3 small, greenish, 2 inner ones often larger and colored. Petals usually 3, more or less forming a tube, or united with sts.; lower petal usually crested. Sts. usually 4+4, forming tube, open on dorsal side, anthers mostly with apical pore; pollen grain characteristic: ovoid, outer membrane splitting longitudinally, inner membrane protruding, resembling barrel staves. Ovary of 5-2 carpels, usually 2-celled, 1 seed in each cell. Seeds often pilose, with growth near micropyle, usually with endosperm. — BH 20, TH 145.



Polygalaceae. — *Polygala dalmatiana;* a: bud two mm., nearly regular, anthers nearly sessile, style tips broad; b: fl. twelve mm., zygomorphic, filaments form sheath, split on upper edge, partly connate with petals, anthers basifixed, opening at top, ovary two-celled, ovules two, pendulous; c: ovary, plac. axile.

Xanthophyllum (*Xanthophyllaceae*, Gagnepain, 1908, fam. nov.; of Wettstein). Trees; sts. separate, plac. parietal.

CELASTRALES

Fls. usually small, greenish. Ste. whorl single, opp. sepals, but in *Rhamnaceae* and *Vitaceae* opp. petals.

Chromosomes:
Aquifoliaceae—*Ilex* 9, 10.
Celastraceae—*Euonymus, Pachystima,* 8; *Celastrus* 23.
Rhamnaceae—*Rhamnus* 10, 12, 13; *Ceanothus, Hovenia* 12; *Zizyphus* 12, 13.
Vitaceae—*Cissus* 16 ?; *Vitis* 19, 20; *Ampelopsis* 20, *Parthenocissus* 30.

167. AQUIFOLIACEAE (Holly Family)

Small trees and shrubs, widely distributed, mainly C. & S. Am.; gen. 3; *Ilex,* inc. Maté or Paraguay tea.

Lvs. alt., mostly evergreen, exstipulate. Fls. small, axillary, perfect or polygamous. Calyx 4-5 parted, petals 4-5, sometimes connate at base. Sts. 4-5, or more, adnate to base of petals, disk none, or inconspicuous. Ovary of 3 or more cells, style short or none. Ovules 1-2 in each cell. Fr. a drupe, of 3 or more 1-seeded carpels. Seed anatropous, pendulous, embryo small, endosperm abundant.—Fam. long placed near *Celastraceae;* some resemblance to *Ebenaceae.*—BH 107, TH 157.

168. CELASTRACEAE (Staff Tree Family)

Shrubs, climbers, trees; widely distributed, mostly Trop.; gen. 40; *Catha* (Arabian tea).

Lvs. opp. or alt., not lobed; stipules small, falling early, or none. Fls. small, greenish. Calyx 4-5 lobed, petals 5. Sts. 4-5, rarely 10, perigynous, disk conspicuous. Ovary free or adherent to disk, 2-5 celled. Ovules usually 2 in each cell. Seed with aril, embryo large, straight, cotyledons flat, in endosperm.—Much resemblance to *Rhamnaceae.*—BH 47, TH 158.

169. HIPPOCRATEACEAE

Mostly climbing shrubs, some small trees; widely distributed in Trop.; gen. 3, inc. edible fruits.

Lvs. usually opp. Calyx small, 5 parted, petals 5. Sts. usually 3, anthers extrorse, disk conspicuous. Ovary more or less confluent with disk, 3 celled, ovule 2-many in each cell. Fr. a capsule or berry. Seeds often winged, cotyledons partly fused, no endosperm. Very near *Celastraceae.* — TH 159.

170. SALVADORACEAE

Trees and shrubs; Trop. Afr. and w. As.; gen. 3.

Lvs. opp., simple, often with small stipules. Calyx 3-4 toothed; 4 petals, free or partly connate. Sts. 4, on or near base of petals; anthers 2-celled, back to back. Ovary superior, 1-2 celled, ovules erect, style short. Fr. a berry or drupe; cotyledons thick, cordate; no endosperm. — Apparently a link between *Aquifoliaceae* and *Oleaceae.* — BH 105, TH 244.

171. STACKHOUSIACEAE

A few small annual or perennial herbs; mostly temp. Australia, also N. Zealand to Philippines; gen. 2.

Lvs. fleshy or leathery, exstipulate. Calyx tubular, 5-parted, petals 5, with claws, free or upper part connate. Disk present, sts. 5. Ovary 2-5 cells, 1 basal ovule in each, carpels separate in fr., central column persistent. Embryo large, in endosperm. — BH 48, TH 160.

172. ICACINACEAE

Mostly trees and shrubs, often climbing; Tropics and Subtropics; gen. 40.

Lvs. mostly alt., exstipulate. Calyx 4-5 parted, sepals 4-5, free or united. Sts. 4-5, filaments often hairy, disk sometimes present. Carpels 3, with 1 style, ovary usually 1 celled with 2 ovules, pendulous. Fr. usually a drupe; embryo small, in endosperm; seed coat 1.

TH 162. — GAGNEPAIN raised *Phytocreneae* and *Cariopterygoideae* to family rank. — FAGERLIND, 1945: Embryology makes it probable *Icacinaceae* belong to *Celastrales* and that there are connections between *Celastrales* and *Ligustrales;* possible connection of *Icacinaceae* also to *Olacaceae.*

173. PANDACEAE

Panda, small tree; Gabun, W. Trop. Afr.; sp. 1.

Lvs. alt., stipulate. Dioec. Ste. fls. in racemes; calyx cup-shaped, petals 5; sts. 5 long, 5 short, rudimentary ovary. Carp. fls. fasciculate on main trunk, no staminodes or disk, ovary 3-4 celled, style 3-4 branched, ovule 1, pendulous from near apex. Fr. a drupe, seed with abundant oily endosperm, cotyledons cordate.

Milbraed, Pflfam. 1931: Engler proposed family and made it a separate order; Hutchinson, between *Cneoraceae* and *Hippocrateaceae*.

174. CYRILLACEAE

American shrubs and small trees; Va. to Brazil; gen. 3.

Lvs. evergreen, entire, exstipulate. Fls. in racemes, small, regular. Sepals 5, often enlarged in fr., petals 5, slightly connate at base. Sts. 5-10, filaments broad; disk none. Ovary 2-4 cells, 1 or 2 ovules in each cell; style short, stigmas 2. Fr. a pod, angled or winged; embryo straight, in endosperm. — Characters of *Cyrilla* suggest *Ericaceae*. — BH 46a, TH 154.

175. CORYNOCARPACEAE

Small trees; N. Zealand, Chatham Ids., Melanesia; gen. 1.

Lvs. leathery, shiny, entire, obovate, exstipulate. Sepals 5, much imbricate, petals 5, adnate to sepals. 5 outer fertile sts., 5 inner staminodia. Disk glands large. Carpels 2, only 1 developing; 1 ovule, suspended. Fr. a flattened drupe; seed coats 2, endosperm none.

TH 156. — Fam. Engler, 1897.

176. RHAMNACEAE (Buckthorn Family)

Shrubs and trees, often spiny, some climbing, Trop. and Temp.; gen. 50; *Zizyphus* (jujube), Chinese fruit.

Lvs. simple, alt. or opp., usually stipulate. Fls. usually small, greenish, in cymes, perigynous or epigynous. Calyx tubular, 5-4 parted, petals concave, 5-4. Sts. 5-4, opp. petals, disk prominent. Ovary 3-2-1-celled, stigmas 2-5. Ovule 1, erect from base. Embryo large, often with endosperm. — *Alphitonia,* seed with large aril. Family characters suggest *Vitaceae;* also *Celastraceae, Araliaceae, Elaeagnaceae, Proteaceae.* — BH 49, TH 169.

177. VITACEAE (Grape Family)

Tendril-climbing shrubs, a few small trees, Tropics and warm Temp.; gen. 10; *Vitis,* inc. European grape, among most ancient of cultivated plants.

Stems jointed; lvs. alt., palmately veined or compound. Fls. small, greenish, in leaf-opposed clusters. Calyx margin 4-5 parted or entire, petals 4-5, often cohering at tips. Sts. 4-5, opp. petals, disk distinct, anthers introrse. Ovary 2-6 cells, 1-2 ovules in each, style short. Fruit a berry. Embryo small, endosperm abundant. — *Leea,* petals and sts. with tubular base. — BH 50, TH 170.

GERANIALES

Mostly herbaceous plants, fls. 5-parted, regular; sts. mostly obdiplostemous, carpels 5 or 3, often separate in fruit.

Chromosomes:

Balsaminaceae — *Impatiens*, 7, 8, 9, 10; *Hydrocera* 8.

Geraniaceae — *Pelargonium* 8, 9, 10, 11; *Erodium* 9, 10; *Geranium* 9, 10, 11, 12, 13, 14.

Limnanthaceae — *Limnanthemum* 5.

Linaceae — *Linum* 8, 9, 10, 12, 15.

Oxalidaceae — *Oxalis* 5, 6, 7, 9, 11.

Tropaeolaceae — *Tropaeolum* 6, 7.

Zygophyllaceae — *Zygophyllum* 11, *Pegamum*, *Tribulus* 12. — WARBURG, 1938: Taxonomy and cytology in *Geraniales: Geraniaceae, Oxalidaceae, Tropaeolaceae* closely related; *Limnanthaceae*, 5 chromosomes, *Balsaminaceae* 7, 8, and 10 chromosomes, less near; *Linaceae* and *Zygophyllaceae* position doubtful.

178. ZYGOPHYLLACEAE

Mostly shrubs and subshrubs in dry climates; Tropics and Subtropics; gen. 25.

Branches often jointed at nodes. Lvs. usually opp., pinnate, with paired stipules. Sepals 5 or 4, usually free, petals 5-4. Sts. 2-3 times number of petals, often with appendages at base, anthers introrse. Ovary usually 4-5 celled, plac. axile, ovules 2 or more in each cell; seeds mostly with endosperm, embryo green. — *Seetzenia* sts. only one whorl. — BH 37, TH 135.

ENGLER, Pflfam. 1931: Nearest *Rutaceae*, differ in usual absence of oil-cells.

179. OXALIDACEAE (Wood Sorrel Family)

Mostly annual and perennial herbs; widely distributed, especially in S. Afr. and S. Am.; gen. 7.

Lvs. palmately or pinnately compound, rarely simple, exstipulate; leaflets bent back in bud and in night position. Calyx 5-parted, petals 5, sometimes slightly connate. Sts. 10, connate at base, 5 sometimes without anthers, sts. and styles often dimorphic or trimorphic. Ovary 5-celled, ovules 1 or more in each cell, plac. axile, styles free, stigmas capitate or shortly divided. Seeds often with elastic testa, endosperm abundant. — *Oxalidaceae* differ from *Geraniaceae* in connate sts., separate styles, and in capsule splitting along dorsal sutures.

TH 130. — Knuth, Pflreich. 1930; Pflfam. 1931: Palmately compound lvs. may be older form than lvs. of *Geraniaceae;* likewise several ovules per carpel.

180. GERANIACEAE (Geranium Family)

Mostly herbs or woody below; many annuals; widely distributed Temp., few in Tropics; gen. 11.

Lvs. palmately lobed, dissected, or pinnate; stipulate. Fls. regular or slightly zygomorphic. Sepals 5-4, persistent, dorsal one sometimes with spur, petals usually 5. Sts. 10-15, outer whorl opp. petals (obdiplostemous: above the whorl of petals there is a break in the regular alternation). Ovary usually 5-celled, with long style or beak, stigmas 5; ovules 1 or 2 in each cell, pendulous, anatropous. Fr. a capsule, when ripe usually separating or bursting into 5 parts, ejecting the 5 seeds. Cotyledons green in seed, folded, endosperm little or none. — Sepals tubular in *Dirachma.*

BH 38, TH 129. — Knuth, Pflreich. 1912: Near *Oxalidaceae, Tropaeolaceae;* also near *Balsaminaceae,* last with different ovule position. Separation of *Oxalidaceae* from *Geraniaceae* not quite natural; stigmas oblong in *Geraniaceae,* globular in *Oxalidaceae;* also near *Linaceae* and *Rutaceae.* — Stroebl, 1925: Obdiplostemony explained by nutrition requirements of sepals in early stages; slight insertion differences are caused by crowded space relations; thus outer sts. are in front of petals in *Geraniaceae, Oxalidaceae, Rutaceae, Saxifragaceae, Crassulaceae, Onagraceae, Ericaceae, Pyrolaceae.* In *Oxalidaceae* and *Caryophyllaceae* base of sts. nearly form a ring.

181. TROPAEOLACEAE

American annual or perennial herbs, creeping or twining, somewhat succulent; Mexico to Chile; gen. 1.

Lvs. sometimes peltate, exstipulate. Fls. zygomorphic, sepals 5, colored, posterior sepal spurred, petals 5. Sts. 8, free. Ovary 3-celled, style 1, stigmas 3. Ovule 1 in each cell, pendulous from apex. Cotyledons thick, endosperm none. — Embryogeny peculiar.

TH 131. — Buchenau, Pflreich. 1902: Form of lvs. of ovary, also embryo development justify family rank; near *Geraniaceae,* perhaps near *Hippocastanaceae.* — Farenholtz, Pflfam. 1931: Highly specialized, isolated; sts. and carpels suggest *Sapindaceae;* spur may be extra staminal disk.

182. LIMNANTHACEAE

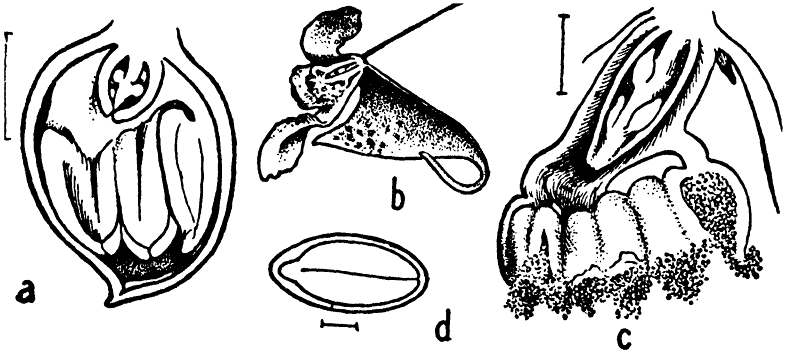
American marsh annuals; Temp. N. Am.; gen. 2.

Lvs. pinnate, exstipulate. Fls. on long pedicels. Sepals 3-5, petals 3-5, contorted. Sts. 6-10, often glandular at base. Carpels 3-5, free or nearly so, connected by gynobasic style, ovule 1, anatropous, in each carpel; in fruit carpels separate into 1-seeded nutlets. Seed erect, embryo straight with large cotyledons, seed coat 1, endosperm none. — Near *Tropaeolum*. — TH 152.

183. BALSAMINACEAE (Jewelweed Family)

Succulent herbs; mostly Asia and Afr., few in N. Am. and Eu.; gen. 2; *Impatiens, Hydrocera.*

Lvs. simple, glabrous, exstipulate. Fls. zygomorphic, brightly colored. Sepals 3, sometimes 5; 2 lateral, small, greenish; 1 posterior, large, petaloid, saccate, spurred. Petals 5 or 3, two lateral ones connate. Sts. 5, filaments short, connate at top. Anthers introrse, somewhat connate around ovary. Ovary 5-celled, plac. axile, ovules several in each cell. Fr. usually a capsule, opening explosively at touch, rarely a berry. Embryo straight, endosperm none. — TH 168.



Balsaminaceae.—Impatiens biflora; a: bud, nearly regular, anthers introrse, ovules axile; b: fl., large sepal forming spur, petals apparently two, two-lobed, representing four petals; c: ovary, filament tube, dehiscing anthers; d: seed, no endosperm.

184. LINACEAE (Flax Family)

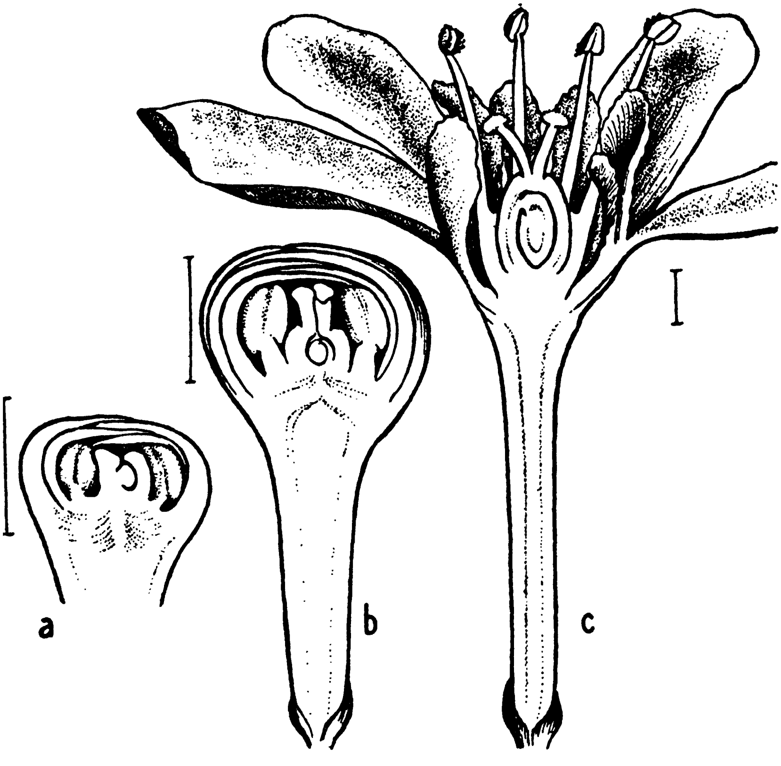
Herbs and shrubs, widely distributed, mainly Temp.; gen. 14.

Sepals 5, petals 5 falling early. Nectar glands 5, sts. 5, connate at base, or many. Ovary 5-celled, or apparently 10-celled, styles 3-5, free with capitate stigmas. Fr. a septicidal capsule; seeds compressed, embryo straight, usually in endosperm. — *Hugonia* Tribe tropical; sts. many; *Linum* Tribe, sts. 5, with 5 staminodes. — BH 34, TH 132.

Humirioideae (*Humiriaceae,* BH 35, TH 133). Shrubs and trees, Trop.

S. Am.; 1 sp. Afr.; gen. 5.—Lvs. alt., exstipulate. Sepals 5, more or less united, petals 5, falling early. Sts. 10 or more, connate below. Disk annular or of separate glands at base of ovary. Ovary 5-7 celled, style 1, ovules 1-3, pendulous from apex. Fr. a drupe.

Erythroxyloideae (*Erythroxylaceae*, TH 134). Shrubs or trees, Tropics and Subtropics, esp. S. Am. and Madagascar; gen. 2. Lvs. simple, entire, with stipules. Fls. small, calyx campanulate, 5-lobed, petals 5, usually with ligule on inside. Sts. 5+5, connate at base. Ovary 3-celled; usually only 1 carpel develops. Fr. a drupe. Ovules pendulous, anatropous.



Linaceae.—*Erythroxylon coca;* a: bud one mm., ovary open; b: receptacle lengthened; c. fl., small bracts, persistent calyx, petals with double ligules, sts. connate below, ovary of two or three carpels, styles separate, stigmas capitate, ovule pendulous.

Winkler, Pflfam. 1931: BH also Wettstein, placed *Linaceae* near *Malvales;* family derived from *Malvales* rather than from *Rosales;* following Hallier's suggestion *Humiriaceae* is reduced to sub-family; the same should apply to *Erythroxylaceae.*

CARYOPHYLLALES

Mostly herbaceous plants, lvs. simple. Fls. mostly 5-parted. Petals when present probably staminodial. Embryo campylotropous, large, curved around perisperm.

Chromosomes:

Aizoaceae — *Sesuvium, Tetragonia* 8; *Mesembryanthemum* 9.
Amaranthaceae — *Digera* 6; *Achyranthes* 7; *Amaranthus* 8, 17; *Celosia* 9.
Basellaceae — *Boussingaultia* 9.
Caryophyllaceae — *Cerastium, Spergula* 9; *Arenaria* 10; *Stellaria* 10, 11, 12, 13; *Scleranthus* 11; *Lychnis, Silene* 12; *Saponaria* 14; *Dianthus* 15; *Gypsophila* 17.
(*Cactaceae:* do they belong here?)
Chenopodiaceae — *Spinacia* 6; *Atriplex, Beta, Chenopodium, Hablitzia, Kochia, Salicornia, Salsola* 9.
Nyctaginaceae — *Bougainvillea, Mirabilis* 10.
Phytolaccaceae — *Petiveria, Phytolacca, Rivina* 9.
Portulacaceae — *Claytonia, Talinum* 6; *Portulaca* 8, 9; *Calandrinia* 8, 10, 11, 12.

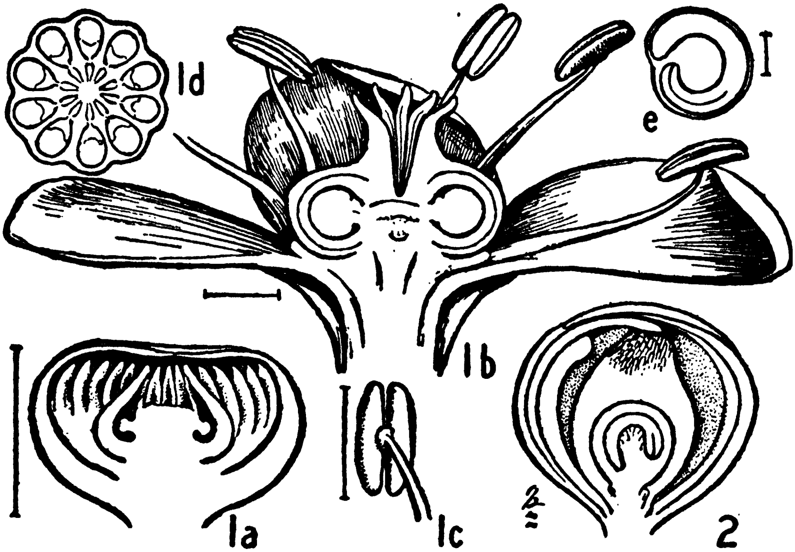
185. PHYTOLACCACEAE (Pokeweed Family)

Herbs, shrubs and trees; widely distributed, esp. warmer parts of Am. and S. Afr.; gen. 24.

Lvs. entire, glabrous. Perianth mostly single, 4-5 parts, free or united at base, persistent. Sts. 3-many, often on disk. Ovary of 1-several carpels, style short, 1 basal ovule in each carpel. Seed erect, embryo large, curved, enclosing endosperm. — In *Limeum* and *Stegnosperma* perianth double; *Agdestis* ovary inferior; *Rivina, Microtea* and others, carpel 1.

Achatocarpus (*Achatocarpaceae,* fam. HEIMERL, 1932, Pflfam. 1934; TH sub *Phytolaccaceae*). Shrubs of Trop. Am.; gen. 2. Stem-growth normal; perianth single. Sts. 10-20, anthers basifixed. Carpels 2, with 1 ovule. Fruit fleshy; seed with perisperm, no aril.

BH 132, TH 83. — WALTER, Pflreich. 1909: *Phytolaccaceae* separated from *Chenopodiaceae* by LINDLEY. PAX derived *Amaranthaceae* and *Chenopodiaceae* from *Microtea,* and along another line *Aizoaceae* and *Nyctaginaceae;* his third line was *Caryophyllaceae* and *Portulacaceae,* but WALTER believed carpels would provide better classification. — BITZEK, 1928: Serum diagnosis and comparative studies support PAX, that *Phytolaccaceae* are primitive in *Centrospermae; Lentibulariaceae* and *Primulaceae* also near this group. —Heimerl, Pflfam. 1934: Family very near those *Nyctaginaceae* with 1 ovule per carpel. — Schaeppi, 1936: *Phytolaccaceae* essentially separate carpels; family probably derived from *Ranales.*



Phytolaccaceae. — 1, *Phytolacca americana;* a: bud one mm., ovary open, carpels partly separate; b: adult fl., styles separate, single ovule per carpel; c: anther dorsifixed; d: ovary, ten carpels; e: seed. — 2, *Rivina humilis;* embryo campylotropous (*cf. Primulaceae*).

186. GYROSTEMONACEAE

Australian shrubs; gen. 4.

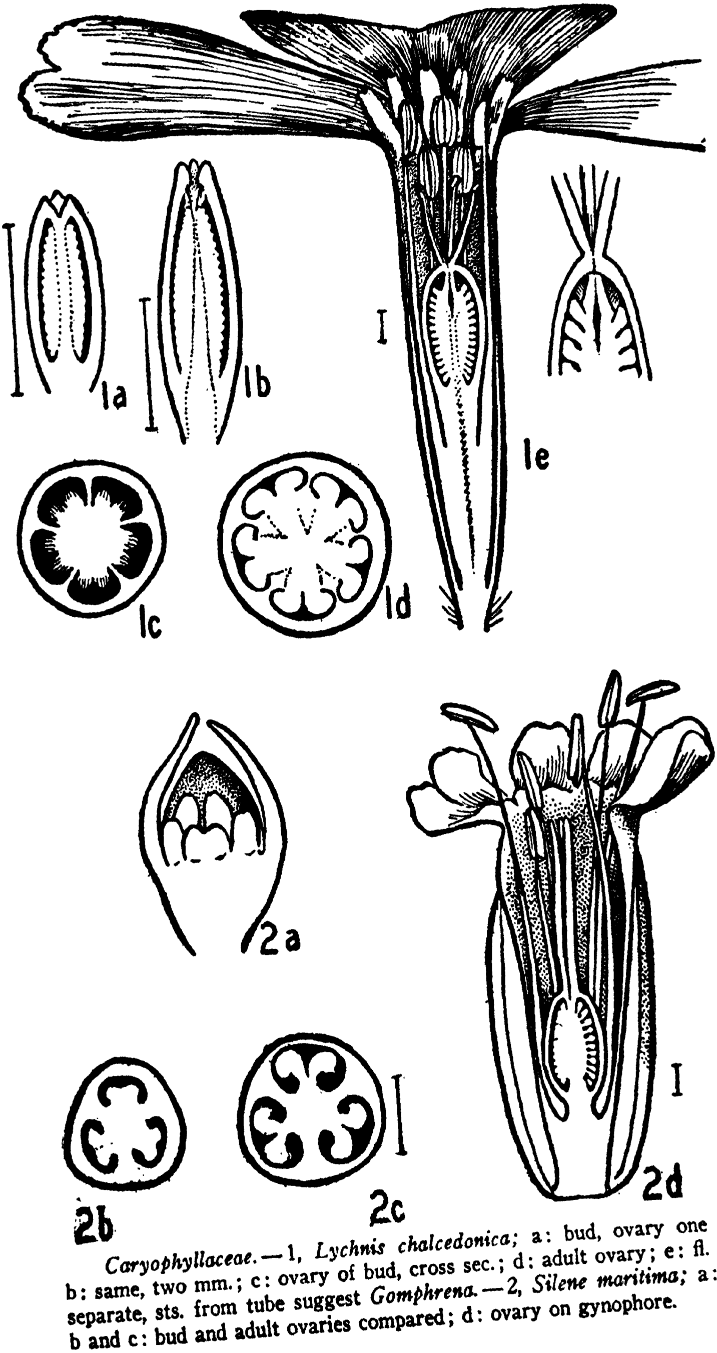
Stem growth normal; lvs. more or less succulent. Fls. unisexual; perianth single. Sts. 6-many, anthers sessile. Carpels usually many, rarely 2-1, 1 ovule in each cell. Seed with aril and endosperm.

Black, 1924, fam. nov. — Heimerl, Pflfam. 1934: Family distinct by anthers, endosperm and by Australian distribution.

187. THELYGONACEAE

Herbs; Medit., Canary Ids., e. Asia; gen. 1.

Lvs. fleshy, stipulate, lower lvs. opp. Monoec.; perianth single. Ste. fls. 2 or 3 together, calyx 2-parted, sts. up to 20. Carp.



Caryophyllaceae.—1, *Lychnis chalcedonica;* a: bud, ovary one mm.; b: same, two mm.; c: ovary of bud, cross sec.; d: adult ovary; e: fl. styles separate, sts. from tube suggest *Gomphrena.*—2, *Silene maritima;* a: bud; b and c: bud and adult ovaries compared; d: ovary on gynophore.

fl. calyx oblique, tubular, style becoming basal by lateral growth of ovary. Ovule 1, erect from base, embryo curved, endosperm fleshy. Seed coat 1. — *Cynocrambeae* Endlicher.

TH 82. — Schneider, 1913: Distinct family, but position disputed; embryo and anthers suggest *Hippuris*. — Ulbrich, Pflfam. 1934: Hallier says near *Haloragaceae*, because of inferior ovary, form of style, embryo, tannin, endoderm; relation probable but fr. differs; resembles *Chenopodiaceae* and *Phytolaccaceae* (*Microtea*).

188. CARYOPHYLLACEAE (Pink Family)

Herbs and undershrubs, mostly N. Temp. Zone, some Arctic, some S. Hemisphere and mts. in Tropics; gen. 70; *Dianthus* (carnation), *Gypsophila* and many garden plants.

Lvs. opp., entire, with swollen nodes. Infl. cymose. Fls. 4-5 parted. Sepals free or united, persistent, petals often clawed. Sts. 8-10 in 2 whorls, sometimes raised on androgynophore. Carpels 5-2, ovules usually many, on central placenta, rarely 1, basal. Fruit a capsule, rarely a berry. Embryo curved around mealy perisperm; in *Dianthus* embryo nearly straight. — *Lyallia* apetalous, sts. 3.

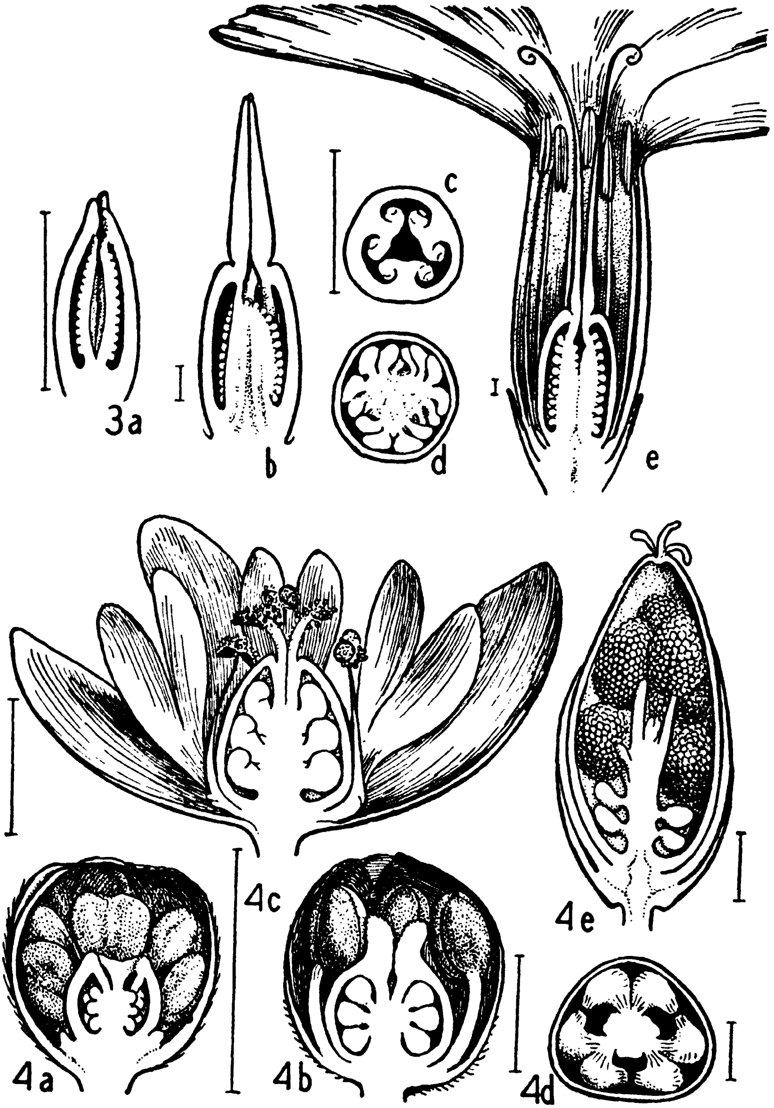
Paronychioideae (*Illecebraceae* of BH, of Gray Man., of Hutchinson) Weedy herbs, sts. on calyx, fr. a 1-seed utricle.

Subfam.? *Dysphania* (TH sub *Caryophyllaceae, Dysphaniaceae* fam., Pax and Hoffman, Pflfam. 1934). Creeping Australian herbs; gen. 1. — Fls. either perfect or carpellate, cyclic. Perianth single, 3-1 parts. Sts. 3-1. Fruit 1 seeded, embryo slightly curved. — Intermediate between *Chenopodiaceae* and *Caryophyllaceae;* valvate sepals, straight sts., distinct fruit.

BH 22, TH 87. — Woodcock, 1927: In seed of *Alsine* starchy perisperm is enriched by embryo; endosperm is a cap of cells over radicle; striking similarity in seed development to *Claytonia* (*Portulacaceae*). — Pax and Hoffman, Pflfam. 1934: *Caryophyllaceae* most advanced of *Centrospermae*. — Rohweder, 1939: n = 15 to 8; chromosomes usually of two sizes; only one size in *Dianthus; Dianthus* nearest ancestral form, as its diploid spp. have smallest ratio chromosomes to nuclear plasma. Where two spp. in genus differ in degree of polyploidy, one annual, other perennial, annual is diploid, perennial polyploid. Older spp. small chromosome-nuclear plasma ratio, younger ones partly high values. —Thomson, 1942: Anatomy indicates *Sileneae* primitive, *Alsineae* (inc. *Stellaria*) reduced; family related to *Primulaceae*.

189. CHENOPODIACEAE (Goosefoot Family)

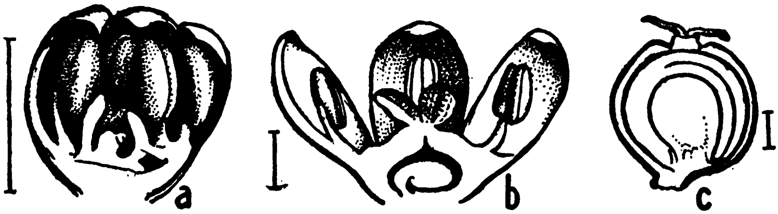
Mostly annual or perennial succulent herbs, some shrubs, many halophytes; small trees (*Haloxylon*), in Central Asia; family cosmopolitan; gen. 75; *Beta* (beet, sugar beet and Swiss chard), *Spinacia* (spinach), *Chenopodium* (inc. *Quinoa*, used as cereal in S. Am.).



Caryophyllaceae.—3: *Dianthus Caryophyllus;* a: ovary, one mm., nearly open; b: ovary, four mm.; c: upper part of ovary, placentae separate; d: lower part, placentae fused; e: fl., styles separate, but connected with placentae (do pollen tubes pass through these connections?).—4, *Stellaria media;* a: bud, ovary one-third mm.; b: ovary, one mm., filaments and stigmas lengthening; c: fl., sepals large, petals deeply cleft, central placenta connected with styles and stigmas; d: sec. ovary; e: fr., pearly ovules, each larger than ovary in 4a, smaller aborted ovules, stigma connections withered, now "free central" placentation, like *Primulaceae.*

Vascular bundles scattered or in concentric circles; lvs. mostly alt., often glaucous, exstipulate. Fls. perfect or unisexual, small, greenish. Perianth single, 5-2 parts; sts. few, free or united at base; carpels usually 2. Ovary 1-celled; ovule 1, basal, campylotropous. Embryo coiled into a ring or spiral, around mealy perisperm. — In *Salsola* embryo nearly fills seed; *Beta* and others have fr. with transverse lid.

BH 131, TH 78. — Ulbrich, Pflfam. 1934: *Polycnema* might be with *Amaranthaceae* or with *Caryophyllaceae.* — Helwig, 1927: *Chenopodiaceae* probably reduced forms.



Chenopodiaceae. — *Beta vulgaris;* a: one mm. bud, ovary open, ovule nearly erect, anthers nearly as large as sepals; b: adult fl., sts. opp. sepals, anthers introrse, ovary half-inferior, stigmas broad, ovule single, campylotropous; c: fr. with embryo curved around perisperm, stigmas persistent.

190. AMARANTHACEAE (Amaranth Family)

Mostly weedy herbs, warm regions; gen. 50.

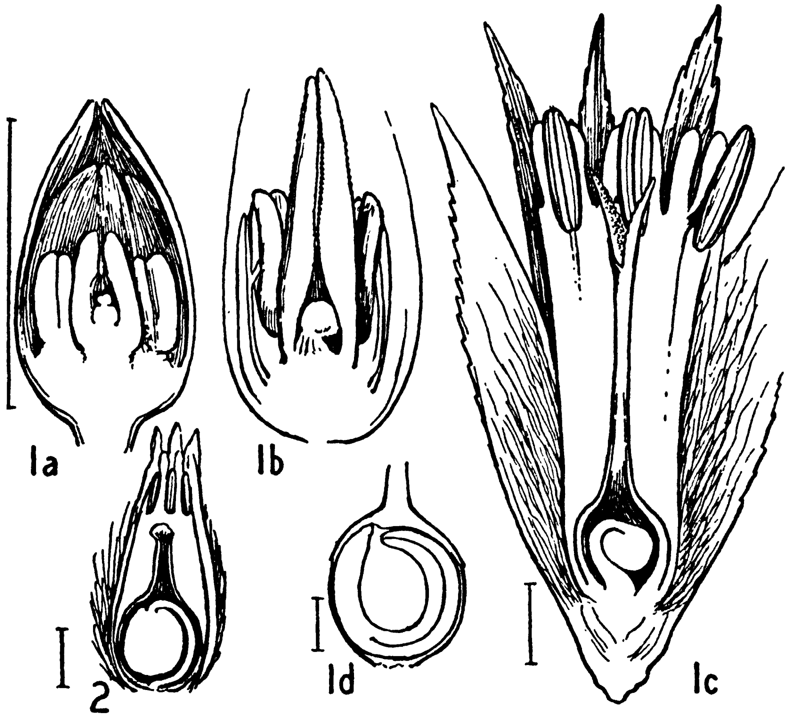
Very near *Chenopodiaceae,* united with it by Baillon. Differs in the dry, membranous bracts, often 3, more or less united. Sts. usually united below. Ovules usually single. Fr. a 1-seeded nutlet, in some genera fleshy. — *Celosia* ovary has several ovules, fr. dehiscence transverse.

BH 130, TH 79. — Schinz, Pflfam. 1934: *Amaranthaceae* and *Chenopodiaceae* separated for convenience, rather than for systematic reasons; very near *Phytolaccaceae,* also near *Portulacaceae, Aizoaceae,* and *Caryophyllaceae.* — Puri and Bahadur, 1935: Life history of *Digera;* he suggests that *Portulacaceae, Basellaceae* and *Caryophyllaceae* should be a separate order. — Souèges, 1937: Proembryo up to octant stage shows marked similarity in *Amaranthaceae, Chenopodiaceae,* and also in *Solanaceae.*

191. BATIDACEAE

Batis, low subshrub, aspect of fleshy *Chenopodiaceae;* on seashores Fla. to Brazil, s. and Lower Calif., Hawaiian Ids.; sp. 1.

Lvs. opp., fleshy. Fls. dioec., green, in 4 rows on fleshy spikes subtended by bracts. St. fls. separate, calyx campanulate, petals 4, claws connate at base, sts. 4, staminodes 4. Carp. fls. united in fleshy spike, perianth none, carpels 2, style none, stigma capitate, ovary 4-celled. Fr. 4-celled, fleshy, endocarp coriaceous. Seeds 4, embryo slightly curved, endosperm none.



Amaranthaceae.—1, *Gomphrena globosa;* a: bud one mm., ovary open, ovule erect, anthers nearly as large as ovary; b: later stage; c: adult fl. with sepals, sts. with short filaments attached to ste. tube (*cf. Caryophyllaceae* and *Primulaceae*); d: fr. with single seed.—*2*: *Froelichia gracilis,* fl. with sepals, ste. tube, ovary with single anatropous ovule (*cf. Plumbaginaceae*).

BH 133, TH 60a.—Hutchinson, 1926: Between *Chenopodiaceae* and *Amaranthaceae.*—Johnson, D.S. 1936: Small, persistent stipules on each leaf and bract; short tracheids; *Batis* has no structures commonly regarded as primitive.

192. PORTULACACEAE (Purslane Family)

Herbs and small shrubs, warm and Temp. Regions, especially w. Am.; gen. 17; *Portulaca,* garden annual; *Lewisia.*

Lvs. entire, fleshy. Sepals usually 2, petals 5-4 or more, or perhaps better interpreted as bracts and petaloid perianth; sts. 4 or 5, opp. petals; or many. Carpels 3, ovary 1-celled, 2-many campylotropous ovules on basal placentae; styles 2-8. Fr. a capsule opening transversely; embryo curved around perisperm.—*Portulaca,* ovary half inferior.

BH 23, TH 85.—Pax & Hoffman, Pflfam. 1934: Nearest *Basellaceae,* also near *Caryophyllaceae* and *Aizoaceae* (*Sesuvium*).

193. BASELLACEAE

Herbaceous, rarely suffruticose, climbing; Trop. Am. and Asia; gen. 5.

Lvs. usually fleshy, alt., glabrous, exstipulate. Fls. small, often with winged bracts. Perianth single, often petaloid, united below, persistent, 5-parted. Sts. perigynous, opp. sepals; anthers introrse. Ovary 1-celled, stigmas 3, ovule 1, basal. Embryo coiled or curved around mealy perisperm.

Ulbrich, Pflfam. 1934: Near *Montia* in *Portulacaceae.*

194. AIZOACEAE

Herbs or undershrubs, often with fleshy lvs., S. Africa, Medit., Australia, Calif.; gen. 18, or many more if *Mesembryanthemum* is divided.

Stem structure anomalous. Lvs. often opp., exstipulate. Fls. perfect, perianth single, often tubular. Sts. 5-many, outer often petaloid. Carpels 2-many, ovules many; embryo curved around perisperm.

Mollugineae (*Molluginaceae* of Hutchinson). Weedy herbs in dry places; fls. small; sepals nearly separate, capsule 3-celled, ovules several in each cell.

BH 79, in same cohort with *Cactaceae,* TH 84.—Pax and Hoffman, Pflfam. 1934.

195. NYCTAGINACEAE (Four O'clock Family)

Herbs, shrubs, trees in warm regions, mostly Am.; gen. 20.

Stem structure anomalous. Lvs. usually opp., often very unequal, exstipulate. Infl. cymose; fls. in involucre. Perianth single, tubular or funnel-shaped, petaloid; lower part persists and envelops fruit. Sts. 1-many. Fruit an akene, seed single, erect. Embryo large, coiled around mealy endosperm; sometimes straight.

BH 128, TH 80.—Hutchinson, 1926, near *Thymelaeaceae.*—Woodcock, 1928: Curved embryo surrounded by perisperm, as in other families of *Centrospermae.*—Heimerl, Pflfam. 1934: Nearest *Phytolaccaceae* but single carpel; also near *Chenopodiaceae.*

POLYGONALES

Single family.

Chromosomes:
Polygonaceae — *Oxyria* 7; *Fagopyrum* 8; *Polygonum* 10, 11, 17; *Rheum* 11.

196. POLYGONACEAE (Knotweed Family)

Mostly herbs, rarely shrubs or trees, chiefly in N. Temp. Zone, few tropical; gen. 40; *Fagopyrum* (buckwheat), *Rheum* (rhubarb).

Lvs. alt., entire, nearly always with ochrea (interpetiolar stipules). Fls. small, sepals 3-6, petals none. Sts. usually 6-9, disk present. Ovary 1-celled, styles 2-4, ovule 1, basal, orthotropous. Fr. a 3-sided or 2-sided nut. Embryo usually curved, endosperm abundant. — *Rumex,* wind-pollinated, pendulous fls., brush-like stigmas; *Rheum* and *Polygonum* have capitate stigmas, nectaries.

BH 134, TH 77. — LAUBENGAYER, 1937: Essentially like *Caryophyllaceae;* funiculus represents a reduced free central placenta; family very homogeneous.

PRIMULALES

Fls. nearly always regular, 5-parted, petals united, rarely separate, sts. single whorl, epipetalous opp. corolla lobes. Ovary 1-celled, ovules on basal columnar placenta, or single basal ovule. Seed with endosperm, 2 seed-coats.

Chromosomes:
Myrsinaceae—*Ardisia* 12, 23.
Plumbaginaceae—*Plumbago* 6, 7; *Ceratostigma* 7; *Armeria* 7, 9, 10; *Limonium* 8, 9
Primulaceae—*Primula* 8, 9, 10, 11, 12, 13; *Androsace* 9, 10; *Lysimachia* 9, 12, 14; *Anagallis* 10, 11; *Cyclamen* 14; *Glaux* 15.—SMITH, W. W., 1933: Remarkable agreement between taxonomy and cytology in *Primula;* most sections have characteristic karyotypes; chromosome number alone of little taxonomic value; in *Primula* size is important: n = 11 most frequent.

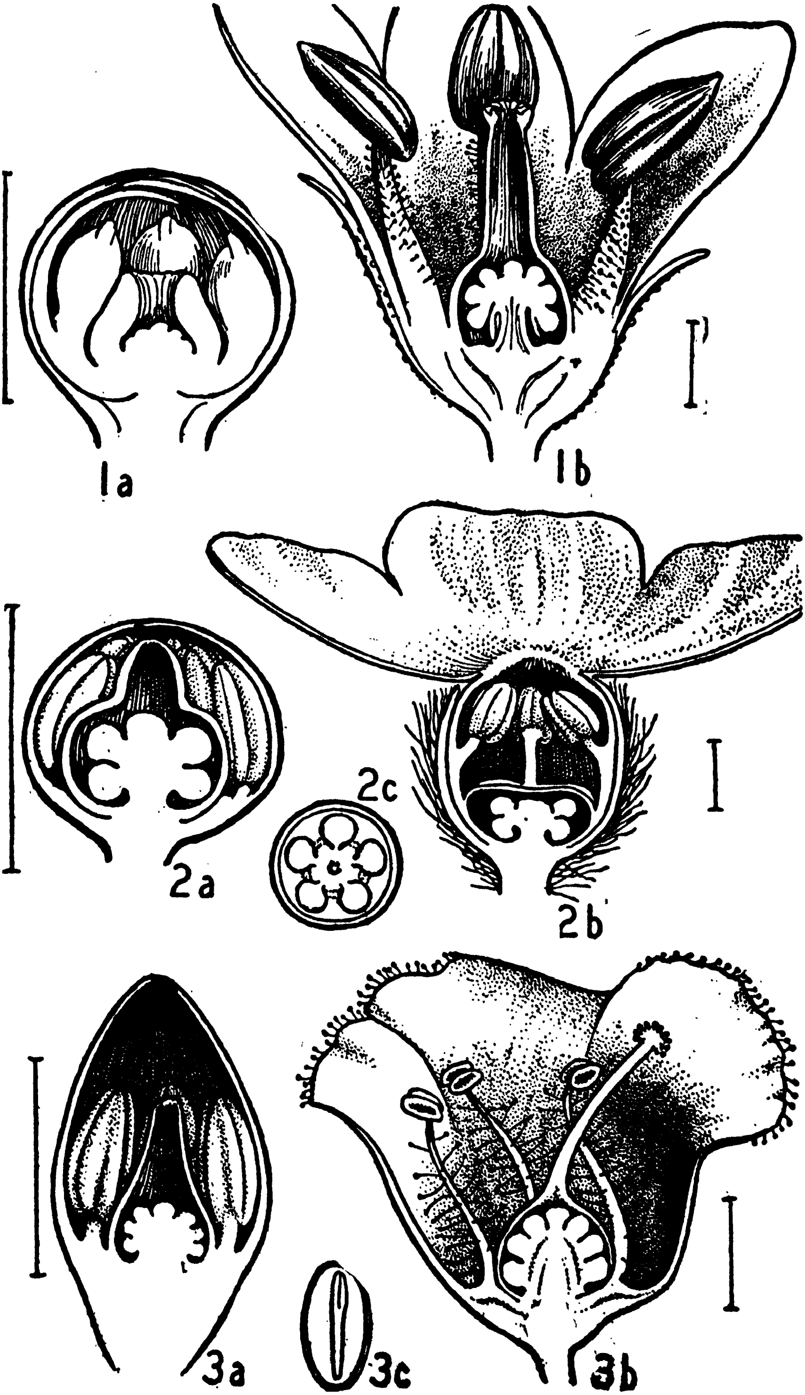
197. THEOPHRASTACEAE

Shrubs and trees; Trop. Am. and Hawaiian Ids.; gen. 4.

No resin ducts. Lvs. lanceolate, exstipulate, often crowded at ends of branches. Calyx 5 lobed, corolla 5-lobed. Staminodia 5, sts. 5, anthers extrorse, connective projecting. Ovary 1-celled, ovules many on central or basal placenta. Fr. a drupe, 2-many seeds; seed coats 2, endosperm present.—*Clavija* filaments form tube.

TH 235a.—MEZ, Pflreich. 1903: Differ from *Sapotaceae* in structure of ovary and in absence of latex.

Primulaceae.—1, *Lysimachia clethroides;* a: ovary open, st. connective projecting, plac. basal; b: fl., sts. opp. corolla lobes, filaments glandular, anthers introrse, plac. central, style tubular. (Is fertilization effected via ovary base?).—2, *Androsace lanuginosa;* a: bud; b: fl., sts. from corolla tube (or is the corolla rather an expansion of a staminate tube?).—3, *Anagallis arvensis;* a: bud; b: fl., corolla lobes, filaments and stigma glandular, sts. from base of corolla tube; c: embryo straight, in endosperm.


1a
1b
2a
2c
2b
3a
3c
3b

198. MYRSINACEAE

Trees and shrubs; mainly in Tropics, widely distributed, gen. 30.

Resin ducts present. Lvs. gland-dotted, exstipulate. Fls. usually small, often very glandular. Sepals united or free, 4-5. Corolla rotate or tubular, rarely free petals, 4-5. Staminodes rare; sts. opp. petals and same number, filaments usually adnate to corolla; anthers sometimes open by apical pores. Ovary superior or half-inferior, 1-celled, style 1, ovules many, often sunk into the central placenta. Fr. usually a drupe, with one or few seeds; seeds with endosperm, embryo straight or slightly curved. — *Embelia* petals separate; *Amblyanthus* anthers connate.

BH 100, TH 236. — MEZ, Pflreich. 1903: Connection *Myrsinaceae* — *Primulaceae* very close, separation artificial; but RADLKOFER rightly separated *Theophrastaceae* from *Myrsinaceae;* still relationship *Primulaceae* — *Myrsinaceae* — *Theophrastaceae* is close.

199. PRIMULACEAE (Primrose Family)

Mostly perennials, some annuals, rarely subshrubs; Cosmopolitan, mainly in Temp. and colder parts of n. Hemisphere; many Arctic and alpine; gen. 25.

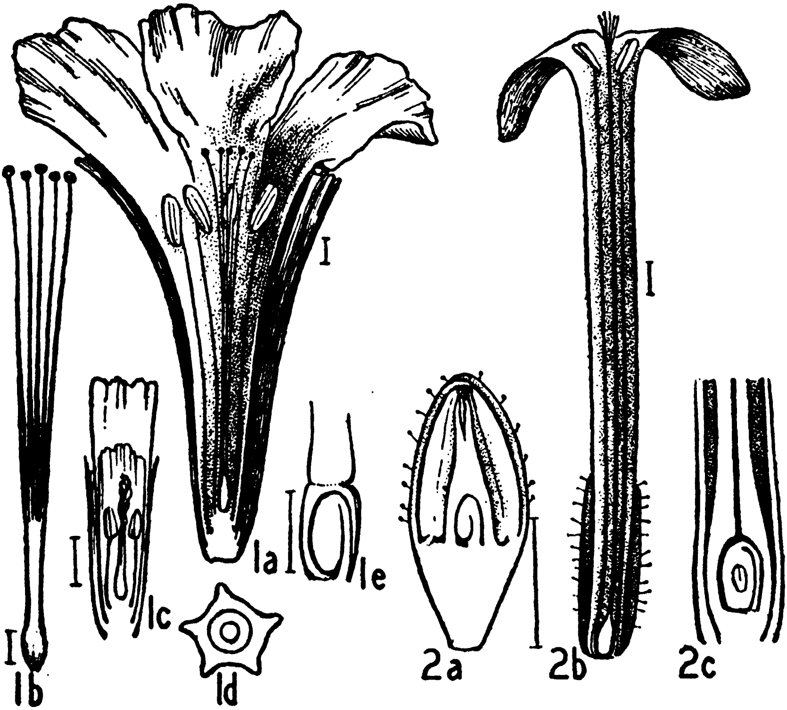
Lvs. often all basal, sometimes cauline, mostly opp. or whorled. Infl. solitary or in umbels, racemes or panicles. Fls. always 5-parted. Calyx persistent, often foliaceous. Corolla tubular, sometimes split nearly to base. Staminodes rare, sts. opp. petals. Ovary superior, rarely half-inferior, 1-celled with central or basal placenta, style 1. Fr. a capsule, seeds usually many; embryo straight, parallel to hilum (amphitropous), seed coats 2; endosperm abundant. — *Hottonia* seeds anatropous; *Samolus* ovary half inferior; *Pelletiera,* fls. trimerous, petals separate; *Anagallis* and *Centunculus* capsules dehisce transversely (*cf. Amaranthus* and *Plantago*).

BH 99, TH 237. — KNUTH, Pflreich. 1905. — HEINRICHER, 1933: Teratological observations of fls. indicate ovules come from carpellary leaves. — WOODCOCK, 1933: *Cyclamen* seed study suggests *Caryophyllales* are related to *Primulales.* — DICKSON, 1936: In floral anatomy irregular fusion of ventral bundles makes interpretation difficult, ovaries indicate *Primulaceae* and *Caryophyllaceae* are related. — DOUGLAS, 1936: Locules at base of ovary in *Primulaceae* suggest ancestors had many-celled ovary and axial placentation; *Sympetalae* not a natural group.

200. PLUMBAGINACEAE

Perennial herbs, some shrubs; cosmopolitan, especially in salt steppes and on seashores; gen. 10.

Lvs. narrow, usually exstipulate. Fls. often in unilateral or subumbellate infl., with membranous bracts. Calyx membranous, often ribbed or plaited. Petals 5, separate or united, often persistent. Sts. 5, often epipetalous, opp. petals or corolla lobes.



Plumbaginaceae. — 1, *Acantholimon glumaceum;* a: fl., sts. opp. corolla lobes, filaments adnate, anthers introrse; b: ovary with five long styles, stigmas capitate; c: bud; d: cross sec. fr. (*cf. Frankenia*); e: long sec. fr. with single seed, basal, anatropous. — 2, *Plumbago capensis;* a: bud, two mm., attachment of sts. at first in line with ovule; b: corolla tube very long, ovule at lower end, anthers at upper end, styles five; c: sec. ovary and seed, embryo straight, in endosperm, (*cf. Frankeniaceae*).

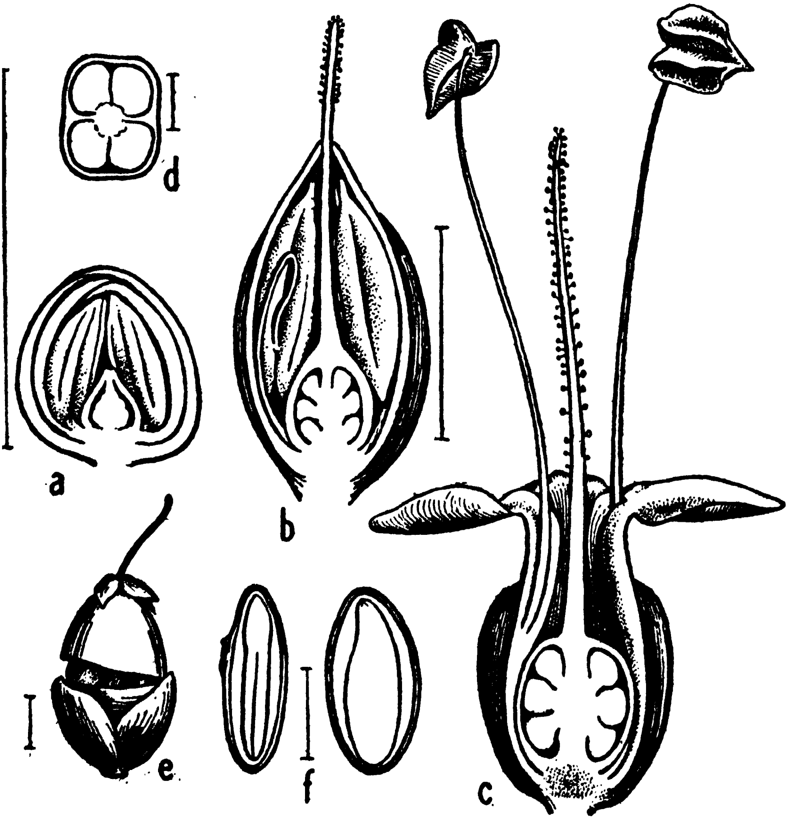
Ovary 1-celled, often 5-ribbed, styles 5; ovule 1, basal, anatropous. Embryo straight, in endosperm; seed coats 2. — Resemblances with *Frankeniaceae,* with *Amaranthaceae,* with *Plantaginaceae.* — BH 98, TH 238.

PLANTAGINALES

Single family.

Chromosomes:

Plantaginaceae — Plantago 4, 5, 6; 2n = 9 (4 + 5). — Ekstrand, 1918: 2n=12 and 24. — McCullagh, 1935: Six chromosome types morphologically recognizable; believes *Plantago* monophyletic, with basic number n = 6.



Plantaginaceae. — Plantago major; a: bud half mm.; b. bud two mm.; c: fl., calyx, corolla, two (of four) sts. with large, introrse anthers, from corolla tube; d: ovary two-celled, plac. axile; e: capsule circumscissile (as often in *Amaranthaceae*); f: seed, embryo nearly straight, in endosperm.

201. PLANTAGINACEAE (Plantain Family)

Mostly perennial stemless herbs, some annual; Cosmopolitan, esp. Medit. and Eastward, also Andes Region; gen. 3; *Plantago Psyllium,* drug plant.

Lvs. usually basal, with fls. small, in spikes. Calyx 4-parted. Corolla sympetalous, scarious, 4-lobed. Sts. 4, epipetalous or hypogynous, exserted. Ovary superior, 1 or 2-celled, ovules 1-several in each cell; style and stigma 1. Fr. a circumscissile capsule or hard nutlet. Embryo parallel to hilum, in endosperm.—In *Bougueria* embryo curved around endosperm (or perisperm?).

BH 127, TH 269.—GRISEBACH long ago interpreted *Plantago* as apetalous, corolla as calyx; compared it with *Plumbago* and *Glaux.*—HENDERSON, 1936: Very early fl. axis shows 5 nearly equal groups of xylem; outer one goes to bract, which may represent a fifth sepal, suggestive of *Acanthaceae* and *Scrophulariaceae;* petals arise in unusual way, as a ring. —PILGER, Pflreich. 1937: *Plantago* probably near *Veronica.*—KENG and KENG, 1945; *Kokonoria,* new genus, w. China.

LOGANIALES

Intraxylar phloem except *Oleaceae*. Lvs. nearly always opp., fls. nearly always regular, mostly 5-parted. Corolla nearly always sympetalous, lobes twisted in bud, except *Oleaceae*. Seed coat 1, endosperm nuclear.

Chromosomes:

Apocynaceae—*Lochnera* 8; *Allamanda* 9; *Trachelospermum* 10; *Apocynum, Nerium* 11, *Vinca* 8, 23.

Asclepiadaceae—*Asclepias, Ceropegia, Gomphocarpus, Hoya, Stapelia, Stephanotis*, 11, *Periploca* 11, 12; *Cryptostegia* 12.

Gentianaceae—*Menyanthes* 9?; *Sweertia* 9, 12; *Gentiana* 13.

Loganiaceae—*Fagraea* 6; *Strychnos* 12; *Buddleia* 15.

Oleaceae—*Jasminum* 13; *Forsythia* 13, 14; *Osmanthus* 22; *Syringa* 22, 23, 24; *Chionanthus, Forestiera, Fraxinus, Ligustrum, Olea* 23.—SAX and ABBE, 1932: Suggestive parallelism between chromosome numbers, grafting possibilities and anatomical wood structure in *Oleaceae*.—TAYLOR, 1945: Basic numbers in *Jasminoideae* 11, 13, 14: *Jasminum, Fontanesia, Forsythia;* basic number 23, rarely 24 in *Syringa, Olea* and *Fraxinus; Oleoideae* only known polyploid group of comparable size with no near relatives having lower chromosome numbers. *See page* 23.

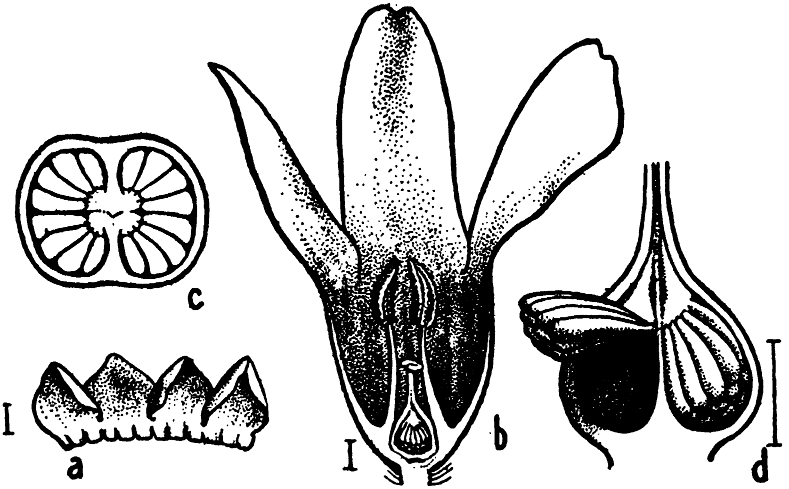
202. OLEACEAE (Olive Family)

Trees and shrubs, some climbers; Cosmopolitan; gen. 20: *Olea* (olive), grown since prehistoric times; *Fraxinus* (ash), *Syringa* (lilac) *Jasminum, Forsythia, Ligustrum* (privet).

Lvs. nearly always opp., simple or pinnate, exstipulate. Peltate hairs common. Fls. mostly small, numerous. Calyx usually 4-lobed, corolla 4-lobed, rarely 6-12 lobed, rarely polypetalous or apetalous. Sts. 2, mostly epipetalous, anthers apiculate, anther cells back to back. Ovary 2-celled, ovules usually 2 in each cell, pendulous or basal; style 1 or none, stigmas 1-2. Embryo straight, endosperm present.—WETTSTEIN makes *Oleaceae* separate order, differing from *Contortae* in placentation, absence of intraxylar phloem, structure of sts., petals often separate.—Several characters in common with *Aquifoliaceae* and *Salvadoraceae.*

Jasminoideae (*Jasminaceae* of LINDLEY, of MÖBIUS). Ovules erect from base.

BH 45, TH 243. — Lingelsheim, Pflreich. 1920: *Fontanesia* is primitive genus in *Oleaceae.* — Weber, 1928: *Oleaceae* fl. structure relatively primitive; family should not be with *Contortae.* — Andersson, 1931: From embryology concludes *Oleaceae* nearer to *Contortae* than to *Celastraceae.*



Oleaceae. — *Forsythia viridissima;* a: bud, corolla tube much shorter than lobes; b: fl., corolla tube nearly as long as lobes, sts. two, from base of tube, style shorter than (or longer than) sts.; c, d: ovary, plac. axile, ovules elongated, suspended.

203. LOGANIACEAE

Trees and shrubs, a few herbs; mostly Tropics and Subtropics; gen. 30; *Strychnos* (strychnine).

Lvs. opp., simple, with free or connate stipules. Calyx 4-5 lobed, corolla tubular, 4-10 lobed. Sts. epipetalous, same number as corolla lobes, rarely 1. Ovary superior, 2-4 celled, style 1; ovules usually many, axile or basal. Fr. usually a capsule; seeds sometimes winged, embryo straight; endosperm present.—*Mitreola* ovary half inferior.

BH 108, TH 245.

Loganioideae. Internal phloem, no glandular hairs, lvs. entire.

Buddleioideae (*Buddleiaceae* of Wettstein). No internal phloem, glandular hairs present, endosperm with haustoria. — Wettstein says *Buddleiaceae* connect with *Tubiflorae, Loganiaceae* with *Rubiales.*

Subfam.? *Desfontainea* (BH, TH, Hutchinson sub *Loganiaceae; Desfontaineaceae* of Diels). American low shrubs; Andes; gen. 1. Fls. large, 5-parted; corolla tube long with contorted lobes. Sts. 5. Ovary 5-celled, ovules many; style long, stigma capitate. Fr. a berry; embryo small, straight, in endosperm.

204. GENTIANACEAE

Perennial or annual herbs, rarely shrubs or small trees; widely distributed Trop. and Temp., also Arctic and Alpine Regions; gen. 70.

Lvs. opp., decussate, rarely alt. or whorled, glabrous, exstipulate. Fls. mostly bright-colored. Calyx tubular or of separate sepals, 4-5 parted, persistent. Corolla 4-8 lobed. Sts. same number as corolla lobes, epipetalous. Ovary nearly always 1-celled, 2 parietal placentae (axile in *Exacum*), ovules many. Fr. usually a capsule; embryo small; endosperm abundant. — In Pflfam. *Exacum* is first genus; last would seem better on account of axile plac. and apical dehiscence of anthers. — *Villarsia* ovary half-inferior; *Pleurogyne*, laminal placentation. — BH 109, TH 246.

Menyanthoideae of BH, H, TH (*Menyanthaceae* Don 1938, of Britton, of Wettstein). Marsh or aquatic perennials, lvs. alt., mostly petioled, gen. 5. — Lindsey, 1938: *Menyanthaceae* family distinction justified by anatomical, floral and other characters.

205. APOCYNACEAE (Dogbane Family)

Trees and shrubs, many climbers, rarely perennial herbs, with milky acrid sap; mostly Tropics; gen. 150, *Landolphia* (African rubber plant), *Oleander* (house plant).

Lvs. opp. or whorled, rarely alt., entire; stipules very rare. Calyx 4-5, parted, corolla twisted in bud, 4-5 lobed, usually with appendices in throat. Sts. 4-5, epipetalous, anthers usually sagittate, connective often produced, pollen grains free or in tetrads. Hypogynous disk usually separate, but united by style and stigma; carpels 2, forming 1- or 2-celled ovary; stigma with fleshy ring. Fr. often follicular, seeds with tufts of long hairs; endosperm usual, embryo straight.

Macfarlane, 1933: From taxonomy and distribution concludes that *Apocynaceae* and *Asclepiadaceae* formerly were upright woody plants, derived from *Loganiaceae;* African genus *Diplorhyncus* primitive, herbaceous plants modern. — Woodson and Moore, 1938: Categories probably vestigial: (1) Calycine squamellae, (2) Corolline scales, (3) Gynoecial nectaries; possible relation with *Rosales;* similar nectaries in *Caryophyllaceae, Primulaceae, Gentianaceae, Convolvulaceae, Solanaceae* and *Caprifoliaceae.*

206. ASCLEPIADACEAE (Milkweed Family)

Herbs and shrubs, somewhat succulent, often climbing, generally with milky sap; widely distributed, mostly in warm climates, esp. abundant in S. Afr.; gen. 250.

Lvs. usually opp., exstipulate. Fls. often small, in umbels. Calyx 5-parted, corolla 5-lobed, with spreading segments, corona between corolla and sts., adnate to one or both. Sts. 5, filaments separate or connate, anthers often adnate to stigma. Pollen granular or in pollinia. Ovaries 2, separate except stigmas, ovules many. Fr. of 2 follicles, seed usually comose. Embryo large, endosperm little.—ROBERT BROWN, 1809, separated *Asclepiadeae* from *Apocyneae* of JUSSIEU.

BH 107, TH 248.

POLEMONIALES

Mostly herbaceous plants, many shrubs, few trees. Corolla sympetalous, mostly zygomorphic, sts. 1 whorl, epipetalous. Seed coat 1, endosperm cellular.

Chromosomes:

Acanthaceae—*Justicia* (7) 14; *Ruellia* 8, 9; *Thunbergia* 7, 9; *Acanthus* 14.
Bignoniaceae—*Tecoma* 9, 10, 17; *Incarvillea* 9, 11; *Catalpa, Bignonia* 20.
Convolvulaceae—*Cuscuta* 7; *Convolvulus* 10, 11; *Ipomoea* 15.
Gesneriaceae—*Saintpaulia* 7, *Gesneria* 12, *Streptocarpus* 15, 16
Hydrophyllaceae—*Hydrophyllum, Nemophila* 9; *Wigandia* 11.
Nolanaceae—*Nolana* 12.
Orobanchaceae—*Orobanche* 19.
Pedaliaceae—*Pedalium* 8; *Sesamum* 8, 13; *Martynia* 15, 18.
Polemoniaceae—*Phlox* 7; *Gilia* 7, 8, 9; *Polemonium* 9.
Scrophulariaceae—*Alonsoa* 6; *Linaria* 6, 7, 8; *Digitalis* 7 or 28; *Antirrhinum, Chelone, Mimulus* 8; *Verbascum* 8, 15, 18; *Calceolaria* 8, 9, 30; *Pedicularis* 8, *Melampyrum* 9, *Scrophularia* 9, 10; *Veronica* 7, 8, 9, 10, 21; *Euphrasia* 11.
Solanaceae—*Petunia* 7, 9; *Nicotiana* 8, 9, 10, 11, 12, American group diploid, Australasian group tetraploid; *Nierembergia* 9; *Schizanthus* 10; *Browallia, Brunfelsia, Salpiglossis* 11; *Atropa, Capsicum, Datura, Lycium, Physalis, Solandra, Solanum* 12; *Hyoscyamus* 14, 17.

207. CONVOLVULACEAE (Morning Glory Family)

Herbs, shrubs, often climbing, and a few small trees. Mainly tropical, but some widely distributed Temp.; gen. 40; *Ipomoea* (sweet potato and morning glory).

Often with milky sap. Lvs. alt., exstipulate. Fls. large, on axillary peduncles, often with 2 bracts. Sepals 5, often separate, persistent. Corolla mostly funnel-shaped, plaited, contorted. Sts. 5, inserted near base of corolla tube. Ovary 2-celled often surrounded by 1-4 celled disk, styles 1-2, stigmas 1-2, ovules 1-2 in each cell. Fr. mostly a capsule; seeds sometimes hairy, cotyledons folded, endosperm mucilaginous. — *Dichondra* carpels separate, styles gynobasic.

Cuscutoideae of BH, TH (*Cuscutaceae* of WETTSTEIN, of BRITTON), parasitic, stems filiform, lvs. none, embryo spirally coiled around endosperm; gen. 1.

Convolvulaceae apart from the following families by milky sap, basal placentation, and large embryo with folded cotyledons. — BH 113, TH 249.

208. POLEMONIACEAE (Phlox Family)

Annual or perennial herbs, a few small trees or climbing shrubs, mostly in N. Am. and Andes, rare in Old World; gen. 10.

Lvs. alt., sometimes lower ones opp., simple or pinnate. Calyx 5-parted, persistent, corolla tubular, 5-lobed, lobes contorted. Sts. 5, epipetalous, anthers introrse. Ovary superior, inserted on disk, 3-celled, rarely 2- or 5-celled; ovules usually many in each cell, style 1, stigma 3, rarely 5. Endosperm abundunt. — *Bonplandia* corolla zygomorphic.

BH 110, TH 250. — BRAND, Pflreich. 1907: Nearest to *Convolvulaceae*. — DAWSON, 1936: From floral morphology concludes family is probably related to *Caryophyllaceae* and *Geraniaceae*.

209. HYDROPHYLLACEAE (Waterleaf Family)

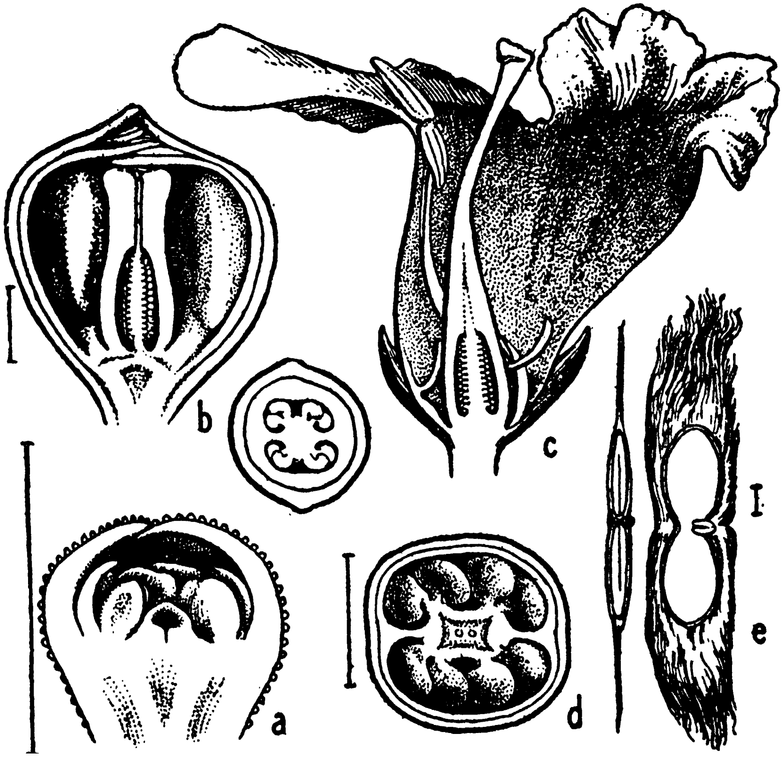
Annual or perennial herbs, rarely subshrubs; mostly Am., from n. e. Asia and Alaska to Strait of Magellan, *Hydrolea* also in Trop. Asia and Afr.; gen. 18.

Plants often hairy or scabrid, sometimes spiny. Lvs. often radical, pinnately or palmately lobed. Calyx 5-cleft, often with appendages between segments, corolla 5-lobed, sts. 5, often hairy below and expanded at base. Ovary 1-celled, with 2 parietal placentae, sometimes 2-celled, styles 1-2, ovules 2-many. Fr. a capsule; seed with endosperm and small, straight embryo. — *Codon* fls. 6-12 parted. Hairyness and scorpioid infl. in family suggest *Boraginaceae*. — BH 111, TH 251.

210. BIGNONIACEAE (Trumpet Creeper Family)

Trees and shrubs, many climbers, few herbs; Tropics and Subtropics, especially Brazil, few Temp.; gen. 10; *Catalpa, Campsis.*

Lvs. usually opp., often once or twice pinnate. Fls. slightly zygomorphic. Calyx 5-cleft, sometimes with appendages. Corolla 5-lobed, tube often gibbous in front. Fertile sts. 4 or 2, didynamous, sometimes also staminodia; filaments long, often hairy below. Ovary of 2 carpels, often on gynophore, style 1, stigmas 2; ovary mostly 2-celled, or 2-celled below, 1-celled above; rarely all 1-celled. *Eccremocarpus* has disk at base of ovary. Ovules many. Fr. a capsule, sometimes fleshy; seeds often large, flat, often winged; no endosperm.



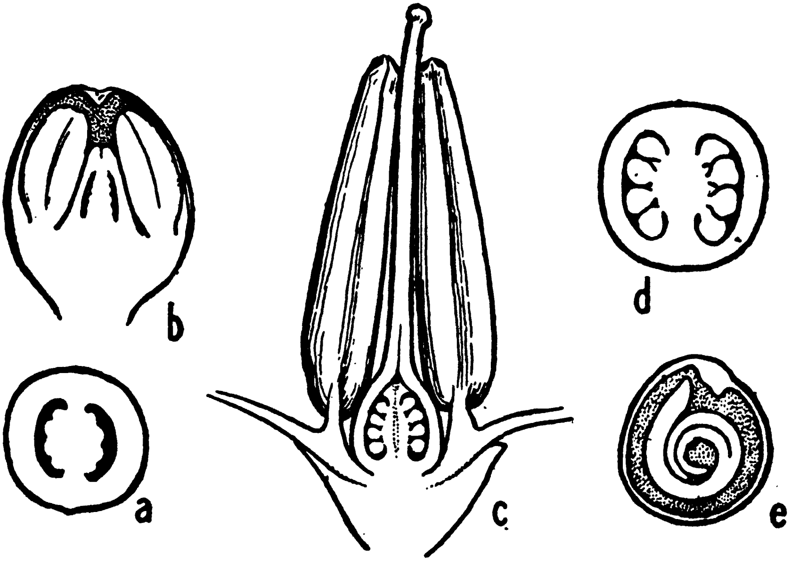
Bignoniaceae. — *Catalpa speciosa;* a: bud, two-thirds mm.; b: bud three mm.; c: fl. zygomorphic showing one st. (of two), anthers united only at top, introrse, small staminodes; d: ovary, plac. axile; e: seed winged on both sides, cotyledons very broad, no endosperm (*cf. Paulownia*).

BH 120, TH 258. — Steenis, 1927: Taxonomy and distribution make it probable that Malayan *Bignoniaceae* have originated from American group.

211. NOLANACEAE

American herbs and small shrubs; w. S. America from Peru to Chile; gen. 3.

Lvs. simple. Fls. solitary, calyx 5-cleft, corolla 5-lobed, plicate in bud. Sts. 5, slightly epipetalous. Ovary of 5 carpels on fleshy disk, ovary lobed, radially and transversely. In fruit 5-30 nutlets, each usually with several seeds.



Solanaceae.—*Solanum Dulcamara;* a, b: bud; c: sts. with short filaments, pistil with long style; d: ovary, plac. axile; e: seed, embryo curved in endosperm.

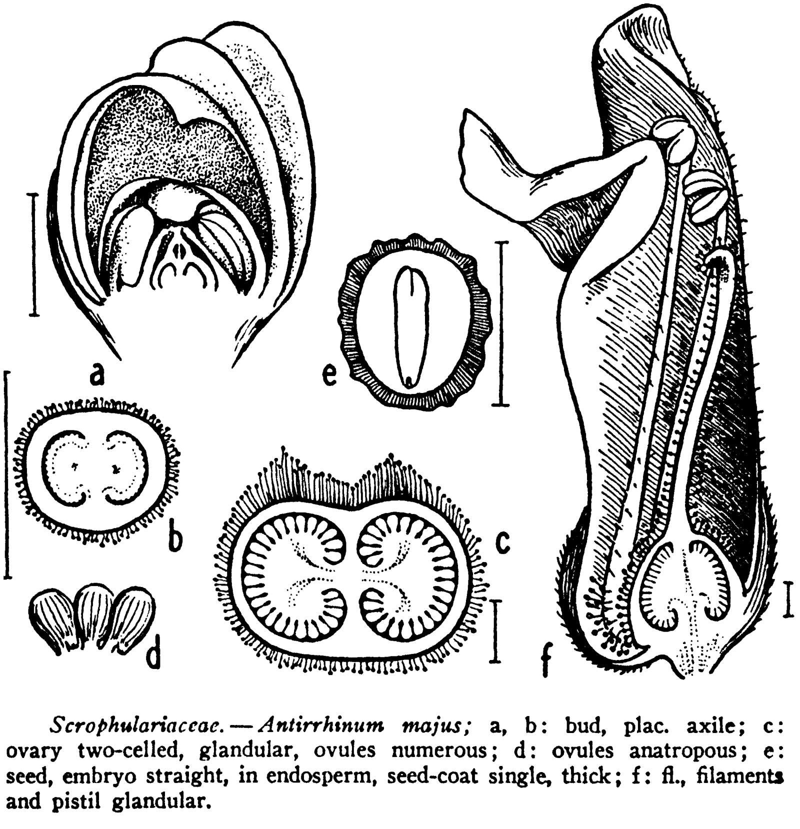
BH sub *Solanaceae,* TH 255.—Hutchinson sub *Convolvulaceae.*—Mirande, 1922: Type of phloem implies *Nolana* belongs near *Solanaceae* rather than near *Convolvulaceae.*

212. SOLANACEAE (Nightshade or Potato Family)

Herbs, erect climbing shrubs, and small trees; Tropics and warm Temp.; gen. 80; inc. potato, eggplant, tomato, tobacco, red pepper, belladonna.

Lvs. simple, often lobed, or pinnately compound or dissected. Fls. usually regular, calyx 5-cleft, corolla 5-lobed, usually plicate in bud, plaited, rotate, campanulate, funnel-form or salver-form. Sts. 5, unequal, epipetalous. Ovary 2-celled, rarely 3-5 celled, carpels generally obliquely placed; ovules many, on swollen axile placentae; style 1, stigma 2. Fr. a berry or capsule; seeds campylotropous or amphitropous, embryo often curved in endosperm. — *Salpiglossis* and others, fls. zygomorphic.

BH 114, TH 256. — Murray, 1946: Comparison of fls. in *Solanaceae* suggests tendency of reduction from 5 to 2 fertile sts., also tendency to zygomorphy.



Scrophulariaceae. — *Antirrhinum majus;* a, b: bud, plac. axile; c: ovary two-celled, glandular, ovules numerous; d: ovules anatropous; e: seed, embryo straight, in endosperm, seed-coat single, thick; f: fl., filaments and pistil glandular.

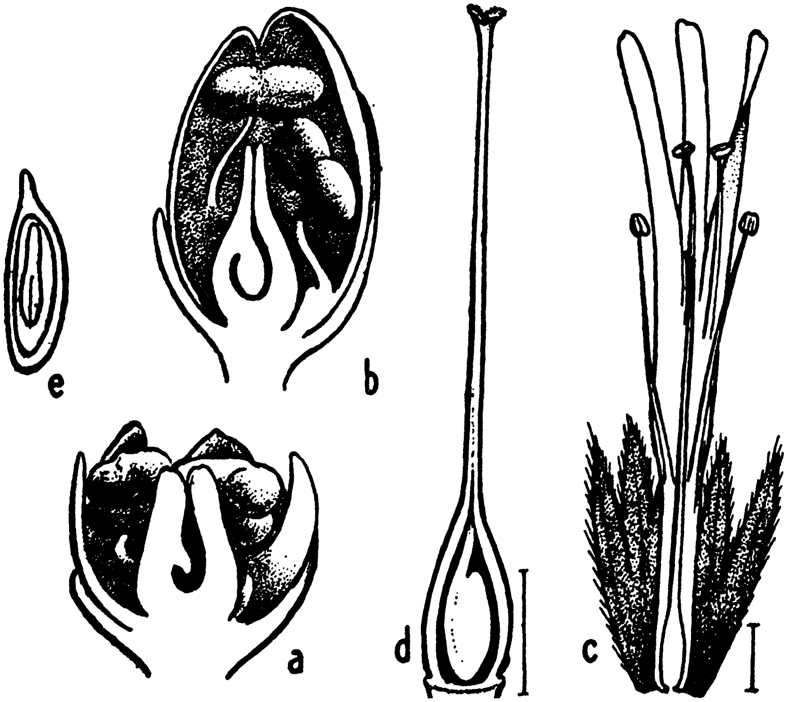
213. SCROPHULARIACEAE (Figwort Family)

Herbs, shrubs, few trees (*Paulownia*); cosmopolitan; gen. 190; many garden plants, such as *Digitalis* (foxglove), *Antirrhinum* (snapdragon), *Veronica.*

Lvs. alt., opp. or whorled, exstipulate. Fls. often bilabiate, throat closed by palate. Calyx 5-cleft, corolla 5-lobed, rarely 6-8 lobed. Fertile sts. usually 4, didynamous, with 1 staminode. Ovary superior, 1-celled, 4 parietal placentae, style 1, stigma 2, ovules many. Fr. a capsule, often enveloped by calyx, rarely a berry; seeds many, small, with endosperm and minute embryo. — *Verbascum* and others, fl. nearly regular, sts. 5; *Paulownia* link toward *Bignoniaceae*.

Selagineae JUSSIEU, of BH. African herbs or undershrubs, sts. 4, nearly equal, ovary 2 cells, each 1 ovule, fr. drupe or akene.

BH 115, TH 257. — PENNELL, 1926: Taxonomy indicates evolution in *Afzelia* (*Seymeria*) proceeded from spp. with corolla campanulate, filaments ribbon-like and ciliate, anther cells with longitudinal dehiscence to those with corolla rotate, filaments slender and glabrous, anther cells dehiscing only near apex; from perennials to annuals along two lines.



Globulariaceae. — *Globularia trichosantha;* a: young bud, ovary open; b: middle stage; c: fl., calyx (spread open), persistent, five-lobed, sec. corolla, sts. didynamous, four, from corolla tube; d: pistil, ovary one-celled, ovule single, pendulous; e: seed, embryo straight, in endosperm. (Partly from PAYER).

214. GLOBULARIACEAE

Old World shrubs or herbs, Medit. and eastward; gen. 3.

Lvs. alt., simple, exstipulate. Fls. bilabiate, in involucrate heads on chaffy receptacle. Calyx 5-lobed, corolla 5-lobed. Sts. 4, didynamous, from top of corolla tube; anthers at first 2-celled, at length confluent and opening by single slit. Ovary superior, 1-celled, ovule 1; style 1, stigma 1-2. Fr. enclosed by persistent calyx; embryo straight, in endosperm. — TH 265.

215. OROBANCHACEAE (Broomrape Family)

Low, brownish, root-parasitic herbs without chlorophyll, widely distributed in N. Hemisphere; gen. 10.

Scales instead of lvs., fls. zygomorphic. Calyx persistent, 4-5 toothed, corolla tubular, usually curved, 2 lipped. Sts. 4, didynamous, sometimes with 1 staminode. Ovary superior, 1-celled, style long, stigma large, 2-4 lobed, ovules many on 4 parietal placentae. Fr. fleshy with pulpy placentae, or a capsule often enclosed by calyx. Seeds small, with endosperm.

BH 116, TH 261. — Beck-Mannagetta, Pflreich. 1930: *Orobanchaceae* might be considered subfamily of *Scrophulariaceae;* also near *Gesneriaceae.* — Glisic, 1929: *Scrophulariaceae* and *Orobanchaceae* agree so fully in endosperm characters, they might be one family; close relationship also in seed development.

Aeginetiaceae Livera, fam. nov. 1927: *Aeginetia, Christisonia* and others; India to Japan, separated from *Orobanchaceae.*

216. LENTIBULARIACEAE (Bladderwort Family)

Aquatics or in moist places, some epiphytes; gen. 5; *Utricularia.*

Lvs. finely dissected or peltate, usually with very small bladder-like lobes, which are traps for minute swimming organisms. Fls. zygomorphic. Calyx 2-5 parted; corolla sympetalous, with spur or sac at base, upper lip 2-lobed, lower 3-lobed. Sts. 2, epipetalous, 2 staminodes. Ovary 2 carpels, 1-celled, ovules many on free central placenta; style 1, stigmas 2. Fr. a capsule; no endosperm. — Corolla and sts. like *Scrophulariaceae,* ovary like *Primulaceae.* — BH 117, TH 264.

217. COLUMELLIACEAE

American shrubs or small trees; Colombia and Peru; gen. 1.

Lvs. opp., simple, exstipulate. Fls. nearly regular. Calyx-tube adnate to ovary, 5-parted. Corolla tube short, usually 5-lobed.

Sts. 2, inserted near base of corolla, anther cells plicate and twisted. Ovary nearly inferior. Ovules many on 2 parietal placentae, nearly reaching middle of ovary. Fr. a capsule, seeds many. Embryo small, in endosperm. — Position of family uncertain, says WETTSTEIN. — BH 118, TH 263.

218. GESNERIACEAE

Herbs, rarely shrubs or small trees, some climbing, mainly Tropics and Subtropics; gen. 100.

Lvs. radical, or opp., simple, often alternately large and small. Fls. zygomorphic, often bilabiate. Calyx tubular, free or adnate to ovary, 5-parted. Corolla with oblique limb, 5 lobed, often gibbous below. Sts. 4 or 2, sometimes with 1 staminode, anthers connate or connivent in pairs, rarely free. Disk or scales present. Ovary superior to inferior, 1-celled, with 2 parietal placentae, ovules many; style 1, stigma 1-2. Fr. a capsule or fleshy with pulpy placentae; seeds small, embryo straight. — *Ramondia* fl. regular. — BH 119, TH 262.

219. LENNOACEAE

American brownish root-parasites, without chlorophyll; s. e. U.S., and Mexico; gen. 3.

Fls. regular, bisexual, 5-many parted. Calyx 4-10 lobed, corolla tubular, 5-8 lobed. Sts. same number as corolla lobes, epipetalous. Ovary 10-15 celled, cells surrounding a thick central axis, each cell spuriously divided, style 1; ovules paired in each carpel, axile. Fr. at last irregularly circumscissile; seeds small, embryo small, endosperm abundant.

BH 97, TH 232. — COPELAND, 1935: Characters suggest *Tubiflorae*, not *Ericales*. Infl. compound thyrse; sepals 4-7, hairs capitate-glandular. Style solid; each carpel 2 ovaries, separated by false partitions. Ovules 1 integ., nucellus feebly developed, no parietal tissue.

220. PEDALIACEAE

Annual or perennial herbs, rarely shrubs; Tropics and Subtrop. Afr., s. e. Asia, Australia; gen. 17.

Plants covered with slime-secreting glands. Lvs. opp., or alt. above. Fls. zygomorphic. Calyx 5-cleft, corolla 5 lobed. Sts. 4, didynamous, often 1 staminode, all from base of corolla; disk present. Ovary superior, rarely inferior, 2-4 celled, style 1, stigmas 1-4. Fr. a capsule or nut; endosperm none. — BH 121, TH 259.

Martynia Subfam.? (BH sub *Pedaliaceae, Martyniaceae* TH 260). Glandular-hairy herbs; Trop. Am., N. Am. to Indiana; gen. 3. Lvs. large, rounded. Fls. zygomorphic, not bilabiate. Ovary of 2 carpels, at least in bud, 1-celled, plac. parietal, ovules several; style 1, stigmas 2. Fr. a curved, horn-shaped capsule; seed coat 1, cotyledons thick.

221. ACANTHACEAE

Mostly herbs, some shrubs, rarely trees, Tropics and Subtropics, few Temp.; gen. 180; *Justicia, Thunbergia, Fittonia.*

Lvs. opp., rarely whorled, often large, exstipulate. Fls. usually bilabiate. Calyx 5-parted, corolla 5-lobed. Sts. 4, epipetalous, didynamous, or 2; filaments free, or partly connate in pairs. Ovary 2-celled on disk, style 1, plac. axile, ovules 2 or more in each cell. Fr. a capsule, often club-shaped; embryo large, endosperm rarely present.

BH 122, TH 266. — MAURITZON, 1934: In 16 genera the early embryo is a row of 3 cells, except in *Thunbergia;* the series, believed phylogenetic from *Ruellia* to *Eranthemum,* shows every stage between nuclear and cellular endosperm; the embryo development is like that of related families.

BORAGINALES

Chromosomes:

Boraginaceae — *Mertensia* 6; *Anchusa* 6, 8, 9, 11; *Lithospermum* 7, 8; *Pulmonaria* 7, 11; *Borago, Echium* 8; *Alkanna* 11, *Heliotropium* 12.
Callitrichaceae — *Callitriche* 3, 5.
Globulariaceae — *Globularia* 10.
Labiatae — *Stachys, Teucrium* 5, 8; *Hyssopus, Rosmarinus, Thymus* 6; *Coleus, Monarda* 6, 8; *Lavandula* 6, 9; *Mentha* 6, 10; *Salvia* 6, 11, 15, 17, 19; *Origanum, Prunella* 8; *Lamium, Nepeta* 9; *Lycopus* 11.
Verbenaceae — *Verbena* 5, 7, 15; *Vitex* 6, 8; *Phryma* 7; *Clerodendron* 12, 23; *Lippia* 16, 18.

222. BORAGINACEAE (Borage Family)

Herbs, shrubs or trees, widely distributed Temp. and Trop., most abundant Medit. and w. N. Am.; gen. 90. *Alkanna* yields red dye; *Heliotropium,* perfume.

Usually with rough or coarse hairs, rarely glabrous, exstipulate. Fls. often in scorpioid cymes. Calyx 4-5 cleft, persistent. Corolla 4-5 lobed, often with scales or folds at throat. Sts. 5, epipetalous, hypogynous disk usual. Ovary superior of 2 carpels, at first 2-celled, but usually separating into 4 one-ovule parts, style usually gynobasic, stigmas 2 or 1. Fruit usually 4-1 seeded nutlets; endosperm scanty or none. — In *Ehretia* and *Cordia* style terminal. (*Ehretiaceae* SCHRADER, 1820, *Cordiaceae* DUMORTIER, 1829).

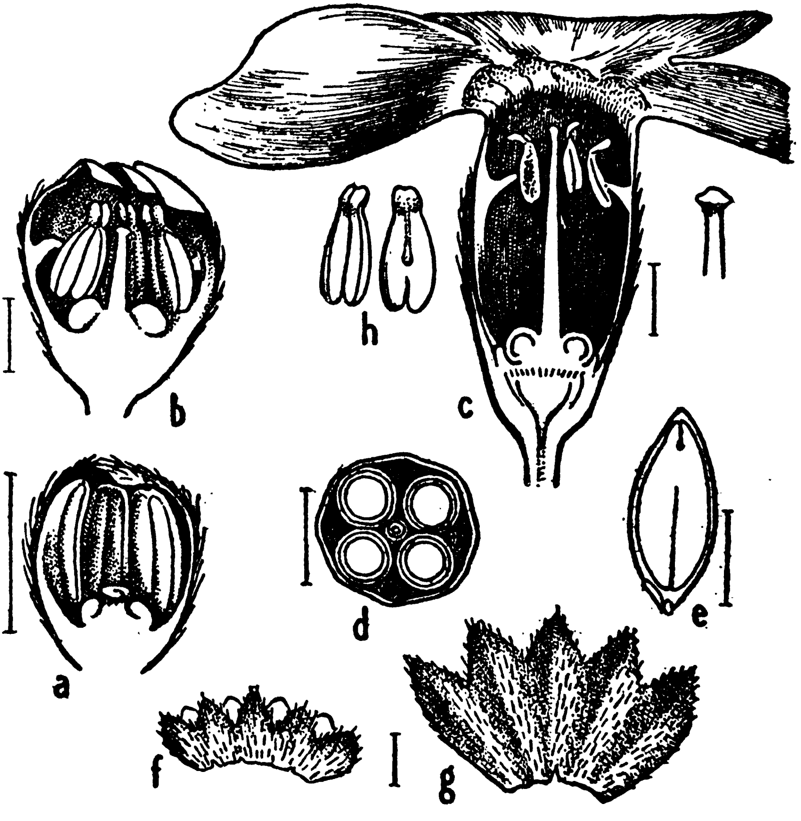
BH 112, TH 252. — BRAND, Pflreich, 1921 and 1931, part. — LAWRENCE, 1937: Family homogeneous, though *Cordia* and *Ehretia* make somewhat distinct subfamilies.

223. VERBENACEAE (Verbena Family)

Mostly shrubs and undershrubs, but many herbs and trees; mostly Tropics and Subtropics; gen. 100 (MOLDENKE); *Tectona* (teak), important tropical Asiatic timber tree.

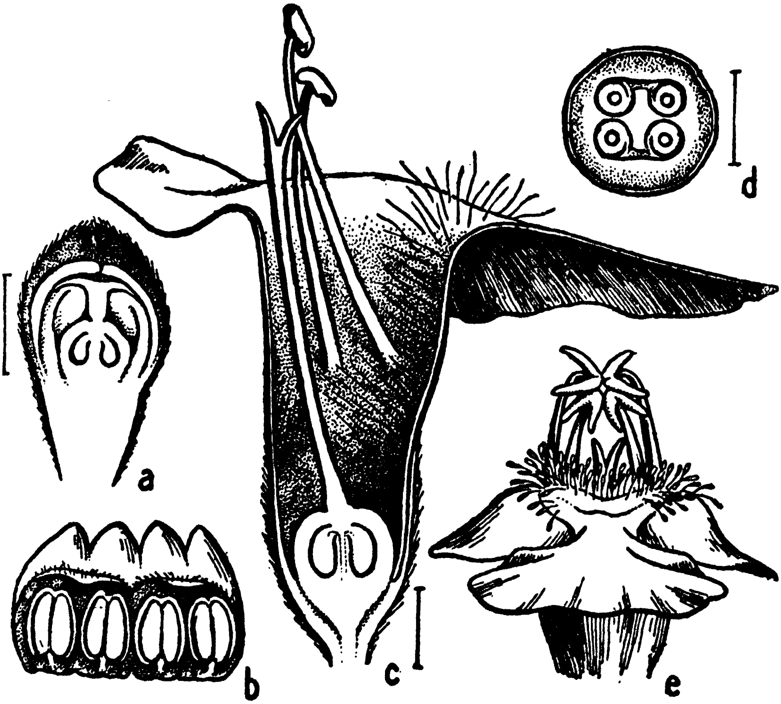
Branchlets often quadrangular; lvs. opp., rarely whorled or alt., simple or compound. Fls. mostly oblique or 2-lipped, calyx

4-5, rarely 6-8 toothed or lobed, persistent, corolla often tubular, 4-5 lobed. Sts. 4, didynamous, rarely 5 or 2, epipetalous, disk often present. Ovary of 2, rarely 4 or 5 carpels, 2-5 celled, or 4-10 celled by false partitions; ovules usually 1 in each cell; style long. Fr. a drupe or dry schizocarp, often separating into drupelets or nutlets; embryo straight, endosperm little or none.—*Tectona* 5 sts.; *Geunsia* 5 sts., 5 carpels.



Boraginaceae.—*Myosotis scorpioides;* a, b: bud one mm. and three mm., sts. at first in line with ovary, later raised; c: fl., corolla tube contracted at throat; d: sec. ovary of four separate nutlets, each with one seed; e: seed, no endosperm; f, g: calyx of bud and of fl. compared, in bud tube and lobes about equal, in fl. tube much longer than lobes; h: sagittate anthers.

Stilboideae Briquet (*Stilbaceae* Lindley 1836, *Stilbinaceae* Möbius 1902). Heath-like shrubs, S. Afr.—*Symphoremoideae* Briquet (*Symphorémacées* Van Tieghem 1898, *Symphoremaceae* Moldenke 1946). Twining shrubs, s. e. Asia, fr. 1 seeded, *Avicennioideae* Briquet (*Avicenniaceae* Endlicher 1843, Black mangroves). Fr. 1 seeded.



Verbenaceae.—*Vitex Negundo;* a: bud two mm. enclosed in calyx, sts. from receptacle, stigma, two cleft, plac. axile, ovules suspended; b: bud, corolla spread open, four sts.; c: fl., zygomorphic, sts. epipetalous; d: ovary with four ovules; e: developing fr., surrounded by persistent calyx.

Phryma (*Phrymaceae* Schauer 1847; BH, also Hutchinson, sub *Verbenaceae*). Perennial, e. N. Am., e. As. Fls. small, in slender spikes, reflexed in fr. Cotyledons convolute.

BH 125, TH 253.—Junell, 1934: *Tectona, Vitex, Clerodendron* and others belong with *Ajuga* and *Prostanthera,* all in *Verbenaceae,* or better in *Labiatae; Stilbinaceae* separate family.

Moldenke, letter 1947: "*Avicenniaceae,* separate family, with growth in diameter of trunks and branches brought about by concentric layers of mestone rings; branches terete, prominently nodose and articulate; calyx subtended by a pseudo-involucre composed of a scale-like bractlet and 2 alternate scale-like prophylla; corolla campanulate-rotate, stamens equal or subdidynamous; ovary with a free central often more or less 4-winged

placenta; ovules 4, pendent, orthotropous, hanging from the top of a central columella; embryo viviparous; plants of saline lagoons.

Phrymaceae, **separate family, with ovary and fruit 1-celled with one erect orthotropous ovule.**

Stilbaceae, **separate family, with distinct endosperm.**

Symphoremaceae, **separate family, with the ovary 2-celled only to the middle, ovules terminal, pendent, orthotropous; inflorescences conspicuously involucrate."**

224. MYOPORACEAE

Shrubs, rarely trees; Madagascar, s. e. Asia, few in W. Indies, Hawaiian Is.; gen. 5.

Lvs. alt., rarely opp. usually glandular or woolly, sometimes scaly or with plumose hairs, exstipulate. Fls. axillary, usually single, zygomorphic. Calyx 5-cleft, persistent. Corolla sympetalous, usually 5-lobed. Sts. 4 or rarely 5, epipetalous; anthers 2-celled, cells often divergent, confluent at apex. Ovary 2-celled, or falsely of several cells, a few pendulous ovules in each cell; stigmas 1-2. Fr. drupaceous. Endosperm little. — BH 123, TH 267.

225. LABIATAE (Mint Family)

Annual and perennial herbs, some shrubs, a few trees (*Hyptis*); cosmopolitan, chiefly Medit. and Orient; gen. 170; usually with fragrant oil; many fragrant herbs, such as pennyroyal, hyssop, lavender, mint, catnip, sages, thyme, etc.

Stem quadrangular; lvs. opp. or whorled, simple, dotted with small glands, exstipulate. Fls. axillary or whorled, usually bilabiate. Calyx often 2-lipped, of 5 variously united sepals, persistent. Corolla tubular, lobes 5 or 4. Sts. 4, epipetalous, didynamous, sometimes 2, anther cells often divergent. Ovary of 2 deeply-lobed carpels, style usually gynobasic; not so in *Teucrium, Ajuga* and Australian genera. Stigmas 2; each carpel lobe has 1 erect ovule. Fr. of four 1-seeded nutlets; endosperm little or none. — According to Briquet eight subfamilies, beginning with *Ajugoideae.* — *See* Fam. 223.

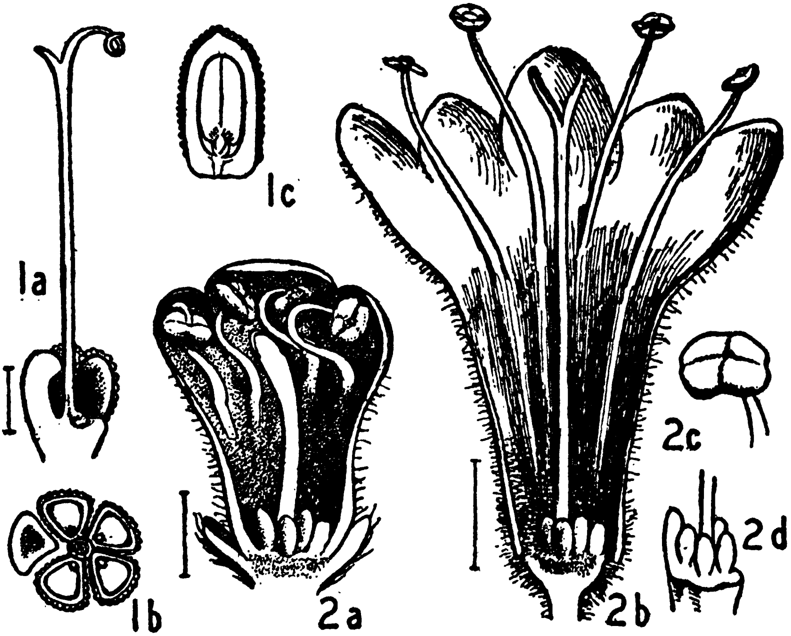
Tetrachondra (*Tetrachondraceae,* Skottsberg, 1913): Fl. 4-parted; may be treated as genus anomalum within *Labiatae,* but that makes family a less natural group; better as separate family. — Used by Wettstein.
BH 126, TH 254.

226. CALLITRICHACEAE

Slender annual, terrestrial or aquatic herbs; cosmopolitan; gen. 1.

Lvs. narrow, opp., entire; land forms have stellate hairs.

Monoec. Fls. small, solitary in leaf axils. Ste. fl. 1 st., anther 4-celled, becoming 1-celled. Carp. fl. 4-celled, surrounded by 2 bracts; styles 2, long. Ovule 1 in each cell, pendulous. Fr. nutlike, 4-lobed. Seed coat 1, embryo somewhat curved, in endosperm.



Labiatae. — 1, *Salvia azurea;* a: ovary with gynobasic style, gland and two nutlets; b: sec. ovary; c: granular nutlet with seed, nearly filled by embryo. — 2, *Iboza riparia;* a: bud three mm., b: fl. spread open, sts. four, nearly alike, style two-lobed; c: anther; d: four nutlets, gland, and base of style.

TH 148. — Schürhoff, 1926: *Callitrichaceae* should be in Warming's order *Nuculiferae,* nearest *Labiatae* and *Boraginaceae;* these families have single integument; archespore is embryo sac mother cell; tapetum present, but in water plants mechanical protection is little developed; fr. of 2 carpels, by false partitions in 4 parts, apparently nutlets; style gynobasic, 2 lobed. Sts. in *Boraginaceae* 5, in *Labiatae* often 2, in *Callitrichaceae* 1. Pollen of *Boraginaceae* and *Callitrichaceae* 3-nuclei. Lvs. *Labiatae* and *Callitrichaceae* opp.; glandular hairs like *Labiatae* and *Verbenaceae.* — Pax and Hoffman, Pflfam. 1931: Position doubtful; possibly near *Labiatae;* Baillon said near *Euphorbiaceae.* — Mauritzon, 1934: Schürhoff has attached too great systematic significance to certain embryological characters.

CAMPANALES

Mostly herbaceous plants. Fls. usually 5-parted. Anthers usually connate. Ovary nearly always inferior, plac. axile, with numerous ovules. Seeds with endosperm, 1 seed-coat.

Chromosomes:
Campanulaceae—*Jasione* 6, 7; *Specularia* 7; *Platycodon* 7, 8?; *Campanula* 8, 10, 13, 14, 17; *Adenophora* 17; *Phyteuma* 18.

227. CAMPANULACEAE (Bellflower Family)

Mostly herbs, rarely shrubs and small trees; mostly Temp.; many are alpines; gen. 60.

Nearly always with milky sap. Lvs. usually alt., exstipulate. Fls. often large, blue, regular in *Campanula* Subfam.; irregular in *Lobelia* Subfam. Calyx tube adnate to ovary, usually 5-lobed, sometimes 3-10 lobed. Corolla tubular or campanulate or bilabiate, rarely polypetalous. Sts. usually 5, from near base of corolla tube, lower part of filaments often connate, anthers introrse. Ovary inferior or half-inferior, rarely superior, generally 2-5, rarely 6-10 and rarely 1-celled; plac. axile, ovules many; style 1, usually with long hairs above, stigmas 2-several. Fr. usually a capsule; seeds small, anatropous, with endosperm, embryo straight. —*Cyananthus,* ovary superior; *Pentaphragma* (*Pentaphragmataceae*), infl. scorpioid, anatomy near that of *Begoniaceae.*—*Jasione,* small fls., capitate.

Cyphioideae (*Cyphiaceae,* of MÖBIUS). Corolla zygomorphic, sts. separate.

Lobelioideae (*Lobeliaceae,* of JUSSIEU, of BARTLING, of GRAY 7 Ed., of HUTCHINSON). Corolla zygomorphic, anthers cohering, fr. often fleshy.

BH 91, TH 276.—ECKHART, 1929: Forms of trichomes indicate *Campanulaceae* and *Cucurbitaceae* are not closely related; these families probably connect with *Choripetalae* at very different points in the system.

228. GOODENIACEAE

Herbs and small shrubs, mainly Australia and Pacific Is., a few in New Zealand, s. S. Am. and Trop. Asia; gen. 10.

Lvs. simple, sometimes all radical, exstipulate. Fls. 5-parted, zygomorphic. Calyx tubular, adnate to ovary, rarely free. Corolla sympetalous, often open on one side, bilabiate, rarely 1-lipped. Sts. 5, anthers free or connivent around style, anthers introrse; pollen deposited into collecting cup at end of style before flower opens, later style bends down and insects receive the powdery pollen, finally stigma-lobes emerge to receive pollen from other flowers. Ovary 1 or 2 celled, inferior or half-inferior, rarely superior. Fr. usually a capsule, in *Scaevola* drupaceous; seed with endosperm and straight embryo.

BH 90, TH 277.—KRAUSE, Pflreich. 1912: Near *Lobeliaceae*, also near *Brunoniaceae*, but aestivation different.

Brunonia (BH, TH, HUTCHINSON sub *Goodeniaceae*, *Brunoniaceae* R. BROWN, 1816; of DIELS). Perennial silky-haired herb; Australia and Tasmania; sp. 1. Lvs. in basal rosette. Fls. in involucrate head, small, blue. Corolla tube long, lobes 5, narrow, spreading. Sts. 5, filaments free, anthers connate around style. Ovary superior, 1-celled, ovule 1, basal. Fr. a small nut surrounded by calyx segments, spiny; embryo straight, no endosperm.

229. STYLIDIACEAE

Herbs and small shrubs, sometimes moss-like, mostly extra-trop. Australia, also New Zealand, s. e. Asia, Fuegia; gen. 3, mostly species of *Stylidium*.

Lvs. narrow, exstipulate, often forming basal rosettes, or fasciculate on stems. Fls. mostly zygomorphic in racemes. Calyx tube adnate to ovary, lobes 5-7; corolla sympetalous, 5-lobed, lobes usually unequal. Sts. 2, filaments connate into column around style, free from corolla, anthers extrorse. Ovary inferior, 2-celled, or 1-celled at base; style 1, stigmas 2. Fr. usually a capsule; seed with endosperm, embryo very small.

BH 89, TH 278.—MILBRAED, Pflreich. 1908.

UMBELLALES

Fls. 4-5-parted. Calyx lobes small. Sts. 1 whorl, opp. calyx lobes. Ovary inferior, usually of 2 carpels, 2 cells, 1 seed in each cell. Seed with endosperm, 1 seed coat.

Chromosomes:

Araliaceae—*Hedera* 11; *Panax* 11, 12; *Aralia, Fatsia* 12.

Cornaceae—*Aucuba* 8; *Corokia, Griselinia* 9; *Cornus* 10, 11; *Helwingia* 12.

Garryaceae—*Garrya* 11.

Umbelliferae—*Astrantia* 7; *Bupleurum, Eryngium* 7, 8; *Hydrocotyle, Sanicula* 8; *Conium* 8, 9; *Sium* 10; *Angelica, Apium, Coriandrum, Levisticum, Myrrhis, Pastinaca* 11.—SCHULTZ, GOEBEL, 1930: In *Apioideae* chromosome numbers confirm DRUDE-ENGLER arrangement; n = 11, also 10, 9, 8. *Araliaceae* and *Cornaceae* closely related to *Umbelliferae*.—WANSCHER, 1933: Chromosomes in *Bowlesia* and *Azorella* groups, n=8, in *Hydrocotyle* group n=11; 12-series and 11-series of *Araliaceae* may have come from primitive *Umbelliferae.*

230. ARALIACEAE (Ginseng Family)

Shrubs, trees, some herbs; mainly in Tropics, especially Trop. Am. and Indo-Malayan Region; gen. 60; *Hedera* (ivy).

Trees often with palm-like habit, bare stem and crown of large lvs. at top. Lvs. simple or compound, often palmately veined or palmately compound, with stellate pubescence. Fls. small, greenish, whitish or yellow, often polygamous or dioec., often in showy umbels, capitate, or in compound racemes; fls. mostly 5-parted. Calyx small, entire, or 5-toothed. Petals 5 or 3, free or connate. Sts. free, same number as petals, disk on top of ovary. Ovary inferior, 1-several celled, ovule 1 in each cell, pendulous from apex. Fr. a berry or drupe; seed with very small embryo; endosperm abundant.—BH 81, TH 227.

231. UMBELLIFERAE (Carrot or Parsley Family)

Nearly all herbaceous, a few shrubs; N. Temp. and Subtrop. Regions, in Tropics on mts.; gen. 250; inc. parsnip, celery, caraway, anise.

Stem usually hollow, furrowed; lvs. alt., mostly ternately or pinnately compound; in *Eryngium* Yucca-like; petioles with conspicuous sheathing base. Fls. small, in simple or double umbels, with bracts and bracteoles. Calyx tube adhering to ovary, lobes small, usually 5; petals 5. Sts. 5, on disk, which crowns ovary. Styles 2, with swollen base (stylopodium). Carpels 2, with prominent ribs, containing oil cells. Fruit a schizocarp, when fully ripe the carpels separate; central axis of fr. forms carpophore from top of which fruitlets or mericarps are suspended. Seed coat 1, embryo small, endosperm abundant.

BH 80, TH 228. — COULTER & CHAMBERLAIN, 1903: *Umbellales* belong with *Rubiales.* — JURICA, 1922: *Umbellales* should be parallel with *Rubiales; Cornaceae* may be near *Caprifoliaceae;* VAN TIEGHEM says *Pittosporaceae* is near *Umbelliferae.* Sympetalous characters of *Umbelliferae* are: complete cyclic arrangement, seed coat 1, ovule anatropous, absence of parietal tissue in megaspore, complete tetrad of megaspores. — SOUÈGES, 1928: *Carum carvi* has embryo development like some *Solanaceae* and like *Sherardia* (*Rubiaceae*). — JACKSON, 1933: Carpophore peculiar to *Umbelliferae;* it is mostly appendicular, but lower part axial.

232. CORNACEAE (Dogwood Family)

Shrubs and trees, mostly n. Hemisphere, extra-tropical, absent from Australia; gen. 10.

Lvs. opp. or alt., entire, often with conspicuous veins, exstipulate. Fls. variously arranged, often in heads, sometimes, as in some *Cornus,* with large, petaloid bracts. Sepals mostly 4, small or absent; petals 4. Sts. 4. Ovary inferior, 2-celled, rarely 1-10 celled, ovule 1 in each cell. Fr. a drupe or berry; seed 1, pendulous, anatropous; embryo small, seed coat 1, coriaceous, endosperm abundant. — In *Helwingia* fls. grow from midrib of leaf; fl. bud is carried upward by growth of leaf-base.

Corneae, H. B. & K., 1818, sub *Caprifoliaceae* — BH 82, TH 229 — WANGERIN, Pflreich. 1910: Near *Araliaceae* and *Umbelliferae,* but more primitive; also related to *Viburnum* and *Sambucus* (*Caprifoliaceae*).

233. GARRYACEAE

Shrubs and small trees, evergreen; Oregon to s.w. U.S., Mexico and W. Indies; gen. 1.

Twigs 4-angled; lvs. opp., exstipulate. Dioec., fls. in catkin-like racemes. Ste. fl. perianth of 4 separate parts, sts. 4. Carp. fl. no perianth, ovary 1-celled, stigmas 2, thick. Ovules 2, pendulous. Fr. berry-like, with remains of stigmas. Embryo minute, seed coat 1, endosperm abundant.

BH, TH sub *Cornaceae.*—Wangerin, Pflreich. 1910: Superior ovary and single perianth excludes *Garrya* from *Cornaceae;* many resemblances to *Betulaceae* and *Myricaceae,* but *Garrya* ovules are pendulous.—Horne, 1914: *Garrya* distantly related to *Hamamelidaceae; Garrya* and *Aucuba* have been grafted.—Hallock, 1930: '*Garrya* may be considered as epigynous; with cyclic sts., 4-parted fls., reduced sepals, single seed coat, is probably near *Cornaceae,* not primitive; embryo development suggests *Sympetalae,* row of 4 potential megaspores, inner one forms embryo-sac; the fleshy seed is an arilloid growth, each cell elongating radially.

RUBIALES

Lvs. opp. Fls. 5-4-parted. Sts. equal petal number or fewer. Ovary inferior. Seed coat 1, embryo straight, in endosperm usually.

Chromosomes:

Caprifoliaceae — *Abelia, Kolkwitzia* 8; *Viburnum* 8, 9, 10; *Lonicera, Symphoricarpos, Weigela* 9; *Sambucus* 9, 19.

Dipsacaceae — *Cephalaria* 5, 9; *Scabiosa* 8, 9; *Knautia* 8, 10; *Dipsacus* 9; *Morina* 17.

Rubiaceae — *Bouvardia, Houstonia, Oldenlandia* 9; *Pentas* 10; *Cinchona* 10, 11; *Galium* 10, 11, 12; *Rubia, Sherardia* 11; *Coffea, Gardenia, Ixora, Mussaenda, Cephalanthus* 11; *Hoffmannia* 12.

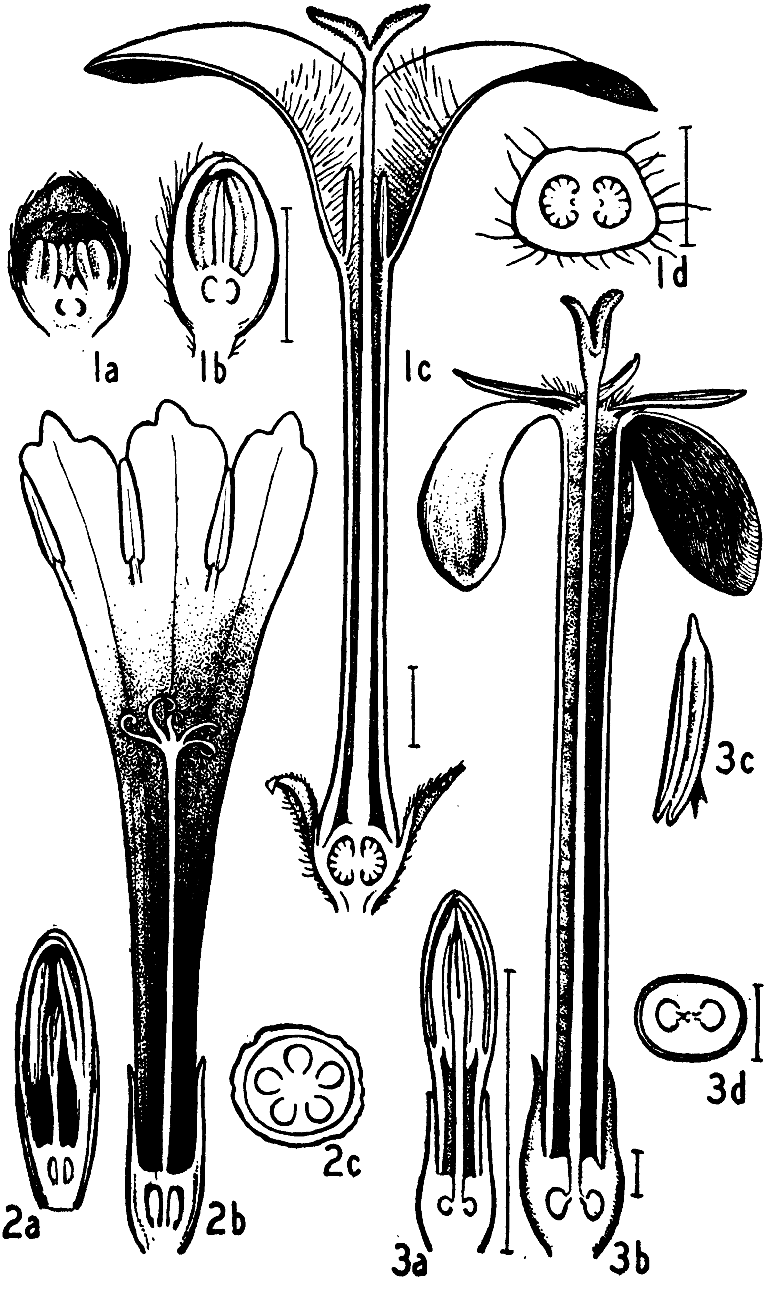
Valerianaceae — *Valeriana* 7, 8; *Valerianella* 7, 8, 9; *Fedia* 8.

234. RUBIACEAE (Madder Family)

Trees, shrubs, a few herbs, such as *Rubia* (madder), *Galium* (bedstraw); widely distributed, mostly in Tropics; gen. 350; *Coffea* (coffee), *Cinchona* (quinine), *Cephaelis* (ipecac).

Lvs. opp., or whorled, simple, usually entire, with stipules. Fls. usually regular, solitary to capitate. Calyx adnate to ovary, 2-6. Corolla tubular, 4-6 lobed. Sts. 4-6, epipetalous. Ovary inferior, mostly 2-celled; ovules 1-many in each cell, plac. axile, basal or apical, rarely parietal; style slender, usually 2 stigmas. Fr. a capsule, berry or drupe. Embryo large, in hard endosperm. — In *Gaertnera* and *Pagamea* ovary nearly free; *Gardenia* plac. parietal, corolla segments contorted. — BH 84, TH 270.

Rubiaceae. — 1, *Pentas carnea;* a: bud one-third mm.; b: bud, one and a half mm.; c: fl., twelve mm., ovary two-thirds inferior; d: ovary, two-celled, plac. axile, ovules many. — 2, *Leptodermis oblonga;* a: bud; b: fl., corolla funnel form, anthers with short filaments, style short (or long), five-lobed, ovary wholly inferior; c: ovary five celled, each cell one ovule. — 3, *Ixora coccinea;* a: bud; b: fl., stigma two- lobed; c: anther versatile, connective projecting; d: sec. ovary.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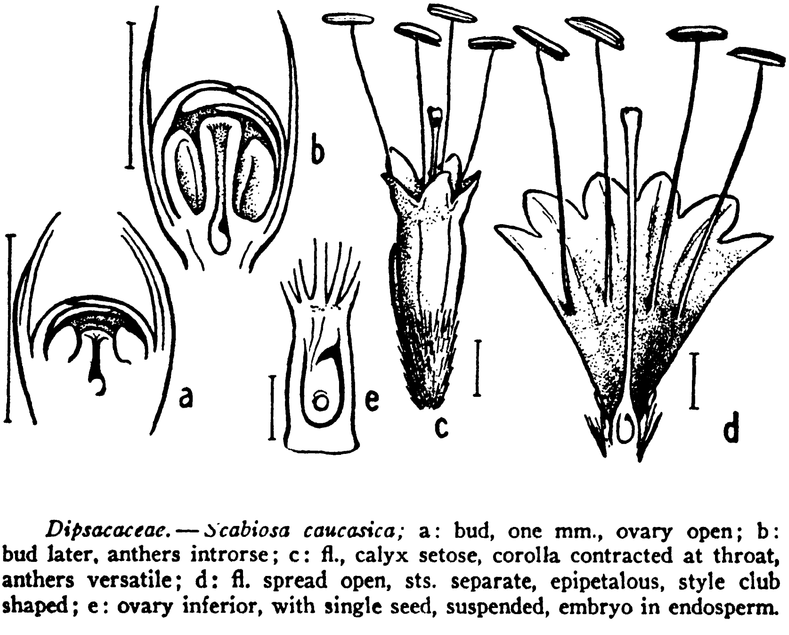
235. CAPRIFOLIACEAE (Honeysuckle Family)

Shrubs (*Lonicera, Viburnum*), rarely herbs (*Triosteum*) or small trees (*Sambucus, Viburnum*), widely distributed, mostly in temperate climates, few in Africa and Australia; gen. 15; closely related to *Rubiaceae.*

Vessel perforations mostly scalariform. Lvs. opp., simple or pinnate, sometimes perfoliate, usually exstipulate. Calyx 5-4 parted, corolla 5-4 lobed, sometimes 2-lipped. Stamens 5-4, epipetalous. Ovary inferior, 2-5 cells, each cell 1-many ovules, pendulous or axile. Style 1 or none, stigmas 1-5. Fr. a berry or capsule. Seed with abundant endosperm, embryo small, straight.



Dipsacaceae.—*Scabiosa caucasica;* a: bud, one mm., ovary open; b: bud later, anthers introrse; c: fl., calyx setose, corolla contracted at throat, anthers versatile; d: fl. spread open, sts. separate, epipetalous, style club shaped; e: ovary inferior, with single seed, suspended, embryo in endosperm.

—In *Sambucus* lvs. are pinnate, stipulate; wood anatomy different.

BH 83, TH 271.—Eames, 1929: *Caprifoliaceae* and *Cornaceae* may be more closely related than commonly assumed; anatomy of fl. reinforces evidence from infl. and wood structure; in *Caprifoliaceae* there is no question from external evidence alone that there has been fusion and reduction of a primitive 5-carpel, 5-chambered condition.

236. VALERIANACEAE (Valerian Family)

Annual and perennial herbs, widely distributed, especially North of Medit., and in S. America; gen. 9.

Plants, especially roots, often strongly scented. Lvs. basal and cauline, opp., simple or pinnate. Calyx of 1-3 minute, often connate sepals; corolla sympetalous, tubular or funnelform, 5 or 3-4 lobed, often with basal spur. Sts. 5 or 4 or 1, epipetalous, exserted. Ovary inferior, 3-celled, only 1 cell maturing; style 1, stigmas 3. Fr. dry, indehiscent, 1-seeded; embryo straight, endosperm none. — *Centranthus,* st. 1. — BH 85, TH 273.

237. DIPSACACEAE (Teasel Family)

Perennial and annual herbs, Medit. and Eastward; gen. 10.

Lvs. opp., rarely whorled, exstipulate. Fls. small, each surrounded by cup-shaped bract, in dense involucrate heads. Calyx small, corolla sympetalous, 4-5 lobed. Sts. separate, usually 4, rarely 2-3, from base of corolla tube. Ovary inferior, 1-celled; style 1, stigmas 2. Fr. an akene, seed 1, pendulous; endosperm little, embryo large.

BH 86, TH 274. — Doll, 1927: Double calyx suggests originally more complex infl.; similarities of embryogeny in *Dipsacaceae, Compositae* and *Calyceraceae;* possible relationship between *Dipsacaceae* and *Calyceraceae;* but not with *Compositae.*

ASTERALES

Mostly herbaceous plants. Fls. in heads subtended by bracts. Sts. single whorl, as many as corolla lobes, anthers connate around style. Ovary inferior, 1-celled, 1 ovule.

Chromosomes:

Cichoriaceae — *Cichorium* 9; *Hieracium* 7, 9; *Lactuca* 8, 9; 2n=17; *Sonchus* 8, 9; *Taraxacum* 8; *Tragopogon* 6.

Compositae Tribes:

Anthemideae — *Achillea, Anthemis, Artemisia, Chrysanthemum* 9.
Astereae — *Aster* 5, 8; *Callistephus, Solidago* 9.
Eupatorieae — *Ageratum* 10, *Eupatorium* 17.
Heliantheae — *Ambrosia* 12, 17, 18; *Coreopsis* 12, 13; *Bidens, Cosmos* 12; *Dahlia* 8, 18; *Galinsoga* 9; *Layia* 7, 8.
Mutisieae —*Gerbera* 23, 25.
Senecioneae — *Cacalia* 10; *Emilia* 5; *Senecio* 10, 11, 12, 23.

238. CALYCERACEAE

American annual or perennial herbs, Temp. and Subtrop. S. Am.; gen. 3.

Lvs. alt., entire or pinnately lobed, exstipulate. Fls. regular, small, crowded in heads, subtended by bracts. Calyx tube angled and dentate, adnate to ovary. Corolla long tubular, 4-6 lobes. Sts. as many as corolla lobes, filaments and anthers more or less connate around style. Ovary inferior, 1-celled, ovule 1, pendulous. Fr. of akenes, which are sometimes connate; embryo straight, endosperm little. — BH 87, TH 279.

239. COMPOSITAE (Composite Family)

Herbs and shrubs, a few are small trees; cosmopolitan. Twelve tribes, nearly 1000 genera, largest family of angiosperms. *Senecio* more than 1500 spp.; *Centaurea, Vernonia,* each more than 500.

Lvs. exstipulate. Fls. in heads, surrounded by involucre, each fl. often subtended by a single bract called chaff. Often outer fls. ligulate (ray-flowers), inner ones tubular (disk-flowers). Calyx called pappus, thread-like or awn-like, or absent. Corolla sympetalous, usually regular, 4-5 lobed. Sts. usually 5, rarely 4, epipetalous, anthers connate around style. Carpels 2, ovary inferior, 1-celled, ovule 1, anatropous; style 2-cleft. Fr. an akene, often crowned by persistent pappus; seed 1, endosperm none. — BH 88, TH 280.

Tribes of *Compositae*. Sequence of BH and Pflam. the same, namely:

1. *Vernonieae* (Ironweed Tribe). Style branches slender.
2. *Eupatorieae* (Boneset T.). Style branches thickened. (*Ageratum, Mikania*)
3. *Astereae*. Style branches flat. (*Solidago, Baccharis*)
4. *Inuleae*. Fls. often papery, anthers caudate. (*Antennaria, Helichrysum*)
5. *Heliantheae* (Sunflower T.) *Dahlia, Zinnia, Cosmos; Ambrosia* carp. fl. single. Receptacle chaffy, pappus none or scaly.
6. *Helenieae*. Receptacle not chaffy. (*Gaillardia, Tagetes*)
7. *Anthemideae*. Involucre often papery, lvs. often deeply cut, aromatic; akenes small. (*Chrysanthemum, Artemisia*)
8. *Senecioneae*. Receptacle naked, bracts few or in one series. (*Tussilago*)
9. *Calenduleae*. Disk fls. with undivided style; ray fls. carpellate.
10. *Arctotideae*. Anthers pointed at base. Mostly S. Afr. (*Gazania*)
11. *Cynareae* (Thistle Tribe). Lvs. often prickly, involucral bracts caudate, pappus delicate. (*Arctium, Carduus, Centaurea*)
12. *Mutisieae*. Corolla two-lipped, anthers long caudate. (*Gerbera*)

240. CICHORIACEAE (Chicory Family)

Herbs, cosmopolitan; nearly 100 genera; *Lactuca* (lettuce), *Tragopogon* (salsify), *Cichorium* (chicory and endive), *Taraxacum* (dandelion).

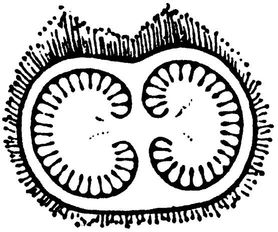
Milky sap, lvs. always alternate; fls. all ligulate, mostly yellow, pollen characteristic. — BH, TH sub *Compositae*.

Cichoraceae, B. de Jussieu, 1759; L. de Jussieu, 1789 (as order); *Cichoriaceae* Reichenbach, 1831; Subfam. *Liguliflorae* DC. 1836, of Pflfam.

INCERTAE SEDIS

Dipentodon (*Dipentodonaceae* fam. MERRILL, 1941); 1 sp. Kwangsi, Kweichow, Yunnan; s.e. Tibet, Upper Burma, 1 sp. — Leaf stipules and perianth suggest *Flacourtiaceae*. Perianth parts 10-14, sepals and petals similar. Calyx tube cup-shaped, free from ovary. Sts. free on edge of perianth tube, opp. outer row of perianth segments, 5-7 prominent glands on calyx tube; pollen grain suggests *Hamamelidaceae*. Lower parts of ovary 3-celled, upper part 1-celled; ovules 2 in each cell at tip of columella, which persists with a single seed, with five aborted ovules at base of seed. Fr. a capsule.

Scyphostegia (*Scyphostegiaceae*, fam. HUTCHINSON, 1926). Remarkable climbing shrub; Borneo; 1 sp. — Dioec. Carp. fl. with cupular disk and six-lobed involucre with several carp. fls. inside, suggestive of *Moraceae*. Seed erect, embryo straight, in endosperm. — BAEHNI, 1937: Not in *Moraceae*, not in *Monimiaceae*.



CONCLUDING REMARKS

Comparing Families:—At present, there remain many problems and uncertainties in the classification of the dicotyledons. The position of a family may often depend on our views about the relationships within the family, we should particularly know which genera may be considered primitive. In this connection the methods of cytotaxonomy and of plant anatomy seem to be especially promising. Comparisons, from many points of view, are needed between families of suspected relationship, such as:—

Monimiaceae and *Calycanthaceae*,
Nymphaeaceae, *Cactaceae* and *Aizoaceae*,
Piperaceae and *Polygonaceae*,
Flacourtiaceae and *Salicaceae*,
Cistaceae and *Papaveraceae*,
Frankeniaceae, *Caryophyllaceae* and *Plumbaginaceae*,
Amaranthaceae, *Plantaginaceae* and *Batidaceae*,
Theaceae, *Ericaceae* and *Cyrillaceae*,
Pittosporaceae and Umbelliferae,
Hamamelidaceae and *Fagaceae*,
Sterculiaceae and *Euphorbiaceae*,
Anacardiaceae and *Juglandaceae*,
Aquifoliaceae, *Salvadoraceae* and *Oleaceae*,
Loganiaceae and Rubiaceae.

Alphabetical and Numerical List of Families:—The Amsterdam International Botanical Congress of 1935 listed the names of 150 families of dicotyledons, besides others, to be conserved. As a result of the general desire not to change the names of families, practical needs received primary consideration. Will such considerations also result in greater uniformity of the scope of families? Or must differences such as *Fumariaceae* versus *Fumarioideae*, and *Vacciniaceae* versus *Vaccinioideae*, continue indefinitely? Recommendations, prepared on an international basis, as to the scope of families seem most desirable. For other groups than the dicotyledons the need is perhaps not so urgent, because the number of families is relatively small. One wonders whether the time is ripe or not for an attempt to prepare a widely acceptable standardized list of the families of dicotyledons (and other groups).

With the aid of a standardized alphabetical family list, the BENTHAM and HOOKER, the ENGLER and other systems could be presented with uniform families, without changing the systems in any essential way. The total number of families of the various systems would then be the same, according to the standardized list. With uniform names and scope of the families, the systems would be readily comparable. The characteristic concepts of a given classification would stand out more clearly and the differences with other systems would also show in a more distinct manner which again would promote further investigation of the essential problems involved.

BENTHAM and HOOKER numbered the families of Phanerogams from 1, *Ranunculaceae* to 200, *Gramineae.* ENGLER, when planning *Das Pflanzenreich* in 1900, assigned numbers, based on the recently completed *Pflanzenfamilien,* from 1, *Cycadaceae* to 200, *Compositae.* Seven years later DE DALLA TORRE and HARMS used nearly the same numbers which are still followed today in many herbaria. As late as 1947 the generic numbers from that work were used in connection with the discussions of the International Commission for Botanical Nomenclature. Numbers are used to designate and classify houses, automobiles, and postal zones. In various branches of science, including systematic botany, they are used for a variety of purposes. Family numbers in herbaria concern a few, but the background for the presentation of information about the vegetable kingdom concerns many.

The classification of plants has developed more or less along individual and institutional, or at most, national lines. If an International List of Plant Families (alphabetical and numerical) could be arranged for, this list, which could be printed on a single sheet, might well develop into a stable basis to be changed only after due consideration, at suitable intervals, by an authorized international group, *e.g.,* by a commission of the newly established International Association of Plant Taxonomists (which includes the International Commission for Botanical Nomenclature).

New discoveries will improve and change our system of plant classification, but practical needs require a certain stability—each of these points of view must be considered. ABRAHAM LINCOLN'S words, inscribed on his statue in Washington, apply well to systematic biology: "I shall try to correct errors where shown to be errors; and I shall adopt new views as fast as they shall appear to be true views."

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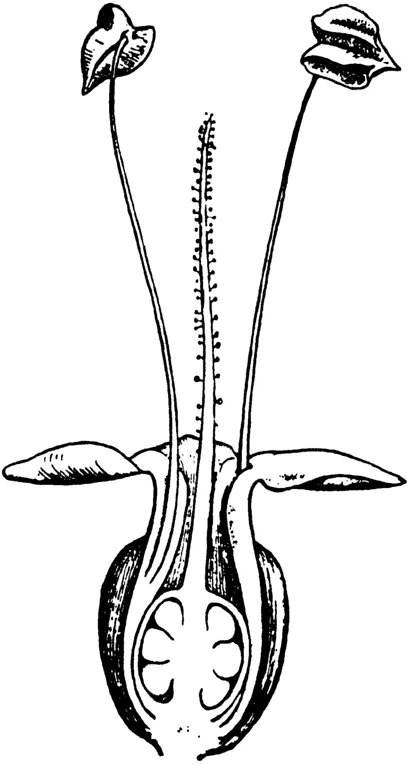

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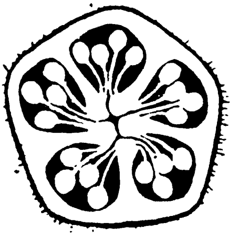

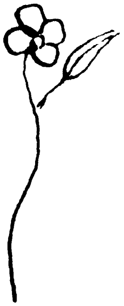

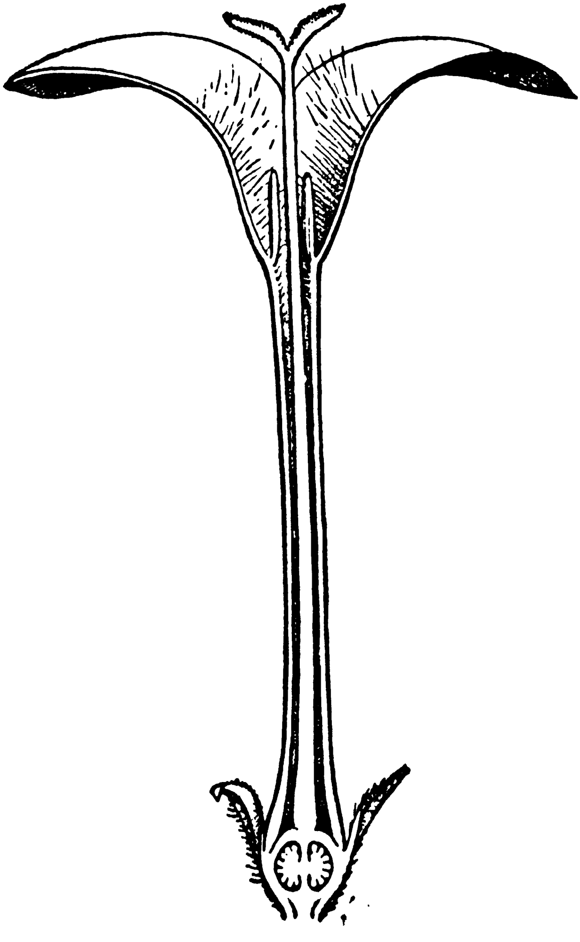

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